# Proceedings of the I·R·E

## Journal of Communications and Electronic Engineering

(Including the WAVES AND ELECTRONS Section)


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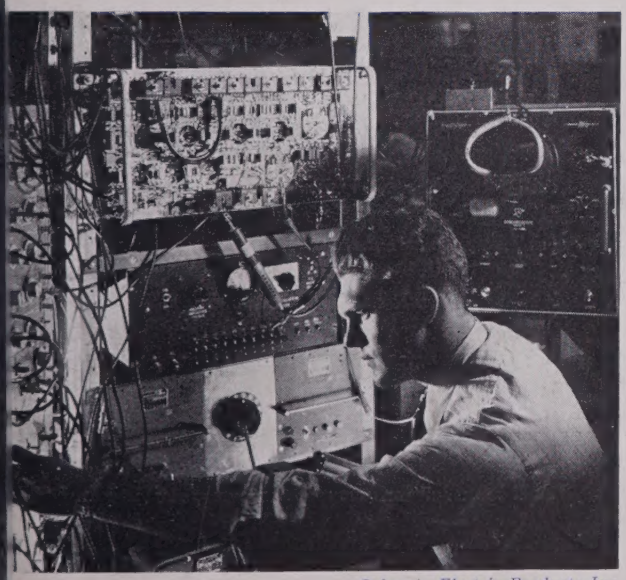
**December, 1949**

Volume 37 Number 12

*Sylvania Electric Products Inc.*

ELECTRONIC-COMPUTER DEVELOPMENT

section of a computer (in the upper middle of the picture) goes systematic tests for necessary precision of its component nts.

The following IRE Standards appear in this issue: Radio Aids to Navigation, Definition of Terms; Railroad and Vehicular Communications, Methods of Testing; Tests for Effects of Mistuning and for Downward Modulation; Piezoelectric Crystals.

PROCEEDINGS OF THE I.R.E.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Circuit Response to Pulses

Diode Phase-Discriminators

Standing-Wave Detector Loading and Coupling Effects

Reflex Oscillator Cavity Losses

Reflex Klystron Beam-Loading Effects

Quantum Interaction of Electrons

Pi-Network Antenna-Coupler Design

IF Noise in Microwave Receivers

Antenna Size and Height for Maximum Signal

Tunable Resonant Cavity Design (Abstract)


Waves and Electrons Section


Clarity in Technical Writing

The Engineer and Industry

Beginning a Career in Engineering

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Resonant Circuits with Time-Varying Parameters

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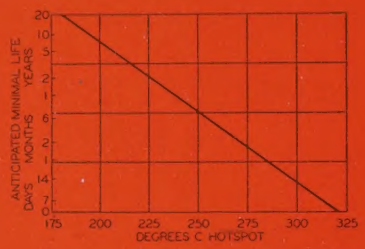
The Institute of Radio Engineers

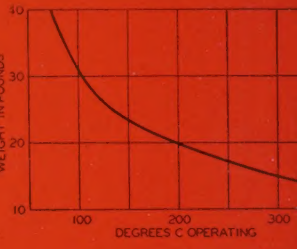
# FOR SPECIALTIES

**The fields of frequency control, Servomechanisms, etc., are developing rapidly with increasing complexity. UTC is playing a principal role in the development of special components for these and allied fields. A few typical special products are illustrated below:**

## SMALLER POWER COMPONENTS

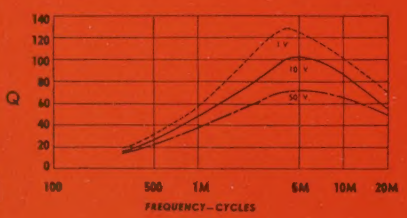
High temperature (class H) insulation, and, in many instances, short life requirements, can effect considerable weight and size reduction where these are important. The curve at the left indicates anticipated life versus temperature rise, using Class "H" insulating materials. The curve at the right illustrates on one typical type the variation in weight with permissible continuous operating temperature.

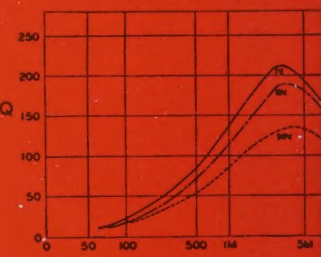



## TOROID DUST HIGH Q COILS

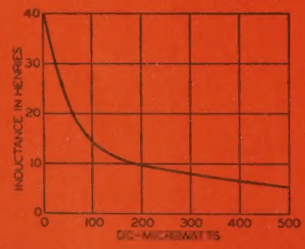
UTC type HQ (permalloy dust) coils have found wide application because of their high Q, stable inductance, and dependability. Four standardized groups of stock coils cover virtually any high Q coil application from 300 cycles to 300 Kc.

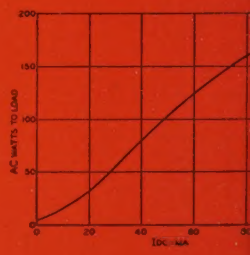



## MAGNETIC AMPLIFIERS

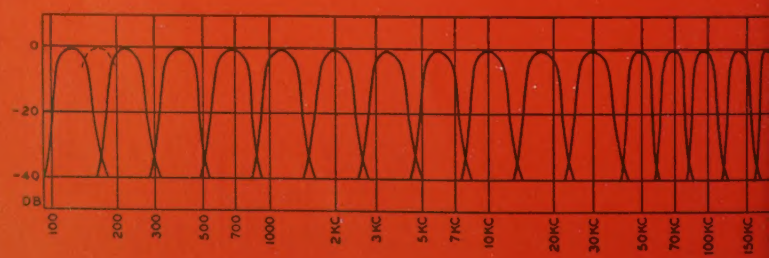
Magnetic amplifiers are used extensively for both power control and phase control. The left curve shown is that of a sensitive saturable reactor structure controllable with powers below .5 milliwatt. The right curve is that of a moderate size power control reactor indicating power to the load with saturating DC.






## AUDIO FILTERS

The curve illustrated shows a group of filters affording sixteen separate bands in the audio and supersonic region with 35 DB attenuation at the cross-over points. These have also been supplied spaced further apart (40 DB cross-over), with intermediate bands, permitting flat top band pass action for any selected range from 100 cycles to 200 KC.

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(Including the WAVES AND ELECTRONS Section)

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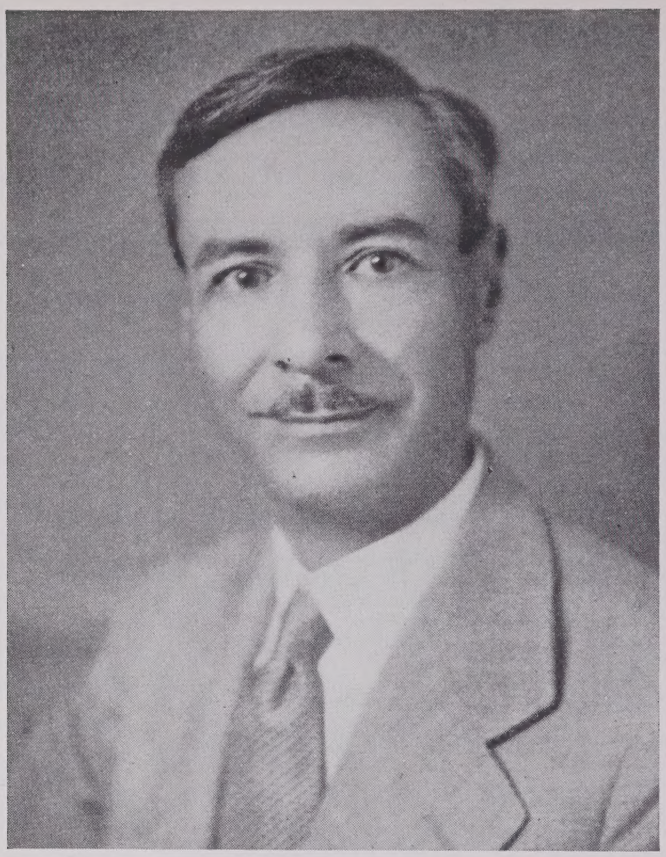

# Haraden Pratt

SECRETARY, 1943–1949

Haraden Pratt, Vice-President and Chief Engineer of the American Cable and Radio Corporation, was born in San Francisco, Calif., on July 18, 1891. He commenced his career in radio as an amateur in 1906, and became a wireless telegraph operator and installer of equipment for the United Wireless Telegraph Company and Marconi Wireless Telegraph Company of America during the years 1910–1914.

Mr. Pratt, who received the B.S degree in electrical engineering from the University of California in 1914, became a construction and operating engineer for the Marconi Company's 300-kilowatt spark-type Trans-Pacific radio stations in California.

From 1915 to 1920 he was an Expert Radio Aide for the Navy Department and was primarily occupied with the construction and maintenance of its high-powered radio stations. Commencing in 1920 he established the public service radiotelegraph system of the Federal Telegraph Company on the Pacific Coast. In 1925 he constructed and operated a radiotelegraph system between Salt Lake City and Los Angeles for the Western Air Express, which was followed in 1927 by development work on radio aids for air navigation of which he was in charge at the Bureau of Standards, Department of Commerce, Washington, D. C. In 1928 he became chief engineer and later vice-president of Mackay Radio and Telegraph Company. He constructed its world-wide communication plant.

Mr. Pratt has attended most international radio and telegraph conferences since 1926 as either a technical or industry adviser. He was a director of the American Standards Association from 1939 to 1942, chairman of the Radio Technical Planning Board from 1945 to 1948, and is now a member of the Joint Technical Advisory Committee.

During World War II he was chief of the National Defense Research Committee's Division 13 on Communications, and in 1948 was awarded a Presidential Certificate of Merit.

Mr. Pratt is a member of Sigma Xi, Fellow of the American Institute of Electrical Engineers, Fellow of the Radio Club of America, and an Associate Fellow of the Institute of the Aeronautical Sciences.

He joined the Institute as an Associate in 1914, became a Member in 1917, and a Fellow in 1929. He has been a Director since 1935, Treasurer in 1941–1942, Secretary since 1943, and President in 1938. Mr. Pratt received the Institute's Medal of Honor in 1944.

By decision of the Board of Directors of the Institute, a major new service to the IRE membership has been established. Its genesis and purpose are described in the following statement from the Technical Editor.—*The Editor.*

# IRE Standards Publication Policy

Standardization is essential to the orderly expansion and progress of a technological field.

The Institute of Radio Engineers, sensible of its responsibilities in this regard, appointed a Committee on Standardization immediately following its foundation in 1912, and the next year published a report dealing with definitions of terms, letter and graphical symbols, and methods of testing and rating equipment. Since that time, standardization activities have played a permanent and prominent role in Institute affairs, resulting in the eventual formation of more than twenty technical committees. These activities have contributed appreciably to the advancement of the electronic and communication art, bringing conformity and clarity to all fields of endeavor.

The Standards publication program of the Institute has been modified from time to time in the past to meet the needs of a rapidly growing field. The initial Standards report of 1913 was succeeded by revised reports appearing in 1915, 1922, 1926, 1928, 1931, and 1933. Each report contained, in a single document, data on all branches of the art. Due to the rapid strides made in certain fields, the Committee on Standardization, during 1924 and 1925, was supplemented with a number of subcommittees, each one of which concerned itself with one specialized branch. As a result of this change in committee structure, the 1926 and subsequent Standards reports each were separated into several sections. Eventually it was found desirable to give these subcommittees full standing-committee status. Accordingly there was initiated in 1938 a new series of Standards in which each Standard dealt with a separate field. More recently, this subdivision has been carried further by the publication of separate Standards within each field on definition of terms, on symbols, and on measuring and testing methods.

The rapid growth of the electronic and communications field has occasioned a correspondingly large increase in Institute membership. As a result, the method of distributing Standards heretofore has become increasingly inadequate. **Therefore, the Board of Directors plans as a continuing procedure, subject to unforeseen contingencies, to publish all Standards, prepared by the Technical Committees of the Institute, in the PROCEEDINGS OF THE I.R.E.** This is regarded as a valuable new service to the membership as it will make available to all members each Standard that is published, thereby ensuring the widest practicable distribution of Standards without additional cost to the members. As a matter of convenience, all issues of the PROCEEDINGS containing Standards will be identified by a red border on the spine and a corresponding notice in red on the front cover. In addition, those individuals who wish to maintain a separate file of IRE Standards may purchase reprints, while available, of those Standards published in the PROCEEDINGS from Institute headquarters.

The Institute is therefore pleased to place before the membership in this issue of the PROCEEDINGS OF THE I.R.E. the first Standards to be published in accordance with the new Institute Standards publication policy.—*The Technical Editor.*

# Standards on RADIO AIDS TO NAVIGATION: DEFINITIONS OF TERMS, 1949*

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## 1. INTRODUCTION

### 1.1. Definition

"Navigation" is the process of finding the position of a vehicle, and directing it to reach a desired destination.

Note: Navigation is inherently three-dimensional. It is often reduced to two dimensions by projecting all positions, courses, and speeds upon the surface of the earth. The measurement of a navigational co-ordinate defines a surface of position. The intersection of this surface of position with the surface of the earth is the conventional line of position. The position of the vehicle is at the intersection of three surfaces of position; it may be so defined or it may be defined as the intersection of two lines of position (at the surface of the earth). Thus altitude is ordinarily dealt with independently as one co-ordinate, while the

* Reprints of this Standard, **49 IRE 12. S1**, may be purchased while available from The Institute of Radio Engineers, 1 East 79 Street, New York 21, N. Y., at $0.60 per copy. A 20% discount will be allowed for 100 or more copies mailed to one address.

other two are converted into horizontal distance and direction or into latitude and longitude. When the vertical component of a course is of comparable importance to the horizontal components it is often advantageous to treat the navigational process in terms of three appropriate surfaces of position.

Note: Navigation is ordinarily carried out continuously throughout a journey. All observed quantities are functions of time.

### 1.2. Conditions

Navigation must be carried on under three sets of conditions that apply at various distances from the starting point, way points, or destination; that is:

*1.2.1.* At distances such that the knowledge of position alone is adequate to determine the proper course to the objective.

*1.2.2.* At distances such that the operation of other vehicles in the vicinity becomes a vital factor in the choice of procedure.

*1.2.3.* At distances such that the relation between the course of the moving vehicle and the positions of fixed bodies, such as docks or landing strips, assume paramount importance.

### 1.3. Operations

Navigation consists of four basic operations: dead-reckoning, fixing, pilotage, and homing.

*1.3.1.* "Dead-reckoning" is the procedure of advancing a known position to give a position at a later time by addition of one or more vectors representing known courses and distances.

Note: One or more of the vectors may represent currents in the sea or air. The distances are ordinarily found by measurements of speeds and time intervals.

*1.3.2.* "Fixing" is the determination of position without reference to any former position.

Note: In case the various elements of a "fix" are not obtained simultaneously, they may be converted to a common time. Having obtained two or more "fixes," at known time intervals, the navigator may determine or verify certain of the vectors which he uses in dead-reckoning.

*1.3.3.* "Pilotage" is navigation without computation of position, by directing a vehicle to its destination through observation of landmarks in the vicinity of the vehicle.

Note: Pilotage may be performed either by direct visual, aural, mechanical, or electronic observation.

*1.3.4.* "Homing" is approaching a desired point by following a route such that some navigational co-ordinate (other than altitude) is held constant.

### 1.4. Radio Fixing Aids

The radio fixing aids to navigation may be classified in terms of the geometrical relation between the vehicle and the known points, lines, or surfaces as follows:

*1.4.1. Single Fixed Vertical Line in Space.* (In two-dimensional navigation, the identification of a single point on the surface of the earth.)

Example: Zone (Z) marker.

*1.4.2. Radial Lines-of-Position*

a. Directional aids—the frame of reference is attached to the vehicle.

Example: Radio direction finding from the vehicle.

b. Azimuthal aids—the frame of reference is fixed with respect to the earth.

Example: Omnidirectional range.

*1.4.3. Distance Measurement*

a. Distance from one or more discrete points. (Circular lines of position.)

Example: Shoran, oboe, or distance measuring equipment (DME).

Note: The measurement involves transmission in both directions over the path. The measurement may be initiated from either the fixed points or the vehicle.

b. Distance from a line. (Cylindrical surface of position.)

Example: Maintenance of a signal of constant amplitude by traveling at a constant distance from a long wire radiating electromagnetic waves with uniform cylindrical symmetry.

c. Distance from a surface. (The surface of position dependent upon the reference surface.)

Example: Radio altimeter (reference is surface of earth).

*1.4.4. Distance-Difference Measurement* (hyperbolic lines of position).

The difference between the distances from two fixed points is measured without knowledge of either distance.

Example: Loran, gee.

*1.4.5. Distance-Sum Measurement* (elliptical lines of position).

The sum of the distances of two fixed points is measured without knowledge of either distance. This process is similar to 1.4.3 a, except that the transmitter and receiver of the transponder are separated by a fixed known distance.

*1.4.6. Composite Aids to Fixing*

The basic processes and co-ordinate systems, outlined above, are not mutually exclusive. They may be combined in a wide variety of ways (including the use of computers) to form numerous specific navigational systems. The various "elements of a fix" (i.e., co-ordinates of position) may be determined by different basic methods, of which the following are typical examples:

a. Polar co-ordinate methods

Examples: Radar-PPI (combining 1.4.2 a and 1.4.3 a), omnidirectional range plus distance-measuring equipment (combining 1.4.2 b and 1.4.3 a).

b. Point identification (combining 1.4.1 and 1.4.3 c).

Example: Zone (Z) marker plus altimeter.

c. Hyperbolic-elliptical co-ordinate methods (combining 1.4.4 and 1.4.5).

d. Intersection of two identifiable surfaces.

Examples: Beam-type instrument approach system (ILS), Ground control of approach radar (GCA).

## 2. DEFINITIONS OF STANDARD NAVIGATION NOMENCLATURE

The following table presents a summary of suggested standard nomenclature (defined elsewhere) as the relation of navigation coordinates to the plan, enroute indication, and result.

| Co-ordinate | Navigational Plan | Instrument Indication | Result |
|---|---|---|---|
| Horizontal Component of Direction | Course | Heading | Course made good |
| Vertical Component of Direction | Slope Angle | Pitch Attitude | Slope angle made good |
| Horizontal Component of Path | Course Line | Position | Track (or Horizontal Track) |
| Vertical Component of Path | Altitudes | Position | Vertical Track |
| Path (3 Dimensions) | Path (or Flight Path) | Position | Track (or Flight Track) |
| Horizontal Component of Speed | Estimated Ground Speed | Speed (any method) | Ground Speed |
| Vertical Component of Speed | Estimated Rate of Climb | Rate of Climb (or Dive) | Vertical Speed |
| Time Schedule | Estimated Time at Each Point | Time (at any point) | Elapsed Time (Between any Points) |

Three terms used in navigation, "bearing," "heading," and "course," are defined on later pages. When these words are used without modifier, the reference direction from which measurements are made is indefinite. Thus, the definitions of these three terms involve measurement of angles from references which are unstated.

A number of modifiers are used with these words to define the reference. For example, we may have "true bearing," "true heading," and "true course." Each of these is defined hereafter. The modifier "true" gives the reference direction as true north. The angles for bearing, heading, and course in their "true" sense can be measured by any desired means.

The modifiers and their reference directions are as follows:

*True.* The reference direction is true north. Azimuth is the same as true bearing. It is suggested, however, that the word "azimuth" be reserved for celestial angles used in navigation and for other purposes, such as surveying. Thus, for purely terrestrial navigational use, the term "true bearing" is preferred.

*Magnetic.* The reference direction is magnetic north.

*Compass.* The reference direction is the north mark on the compass card of a magnetic compass (or repeater). Deviation has an effect on the angle of the north point of the card with reference to magnetic north. Further, the calibration of the compass card may not be correct. However, the reference as stated is the north mark on the compass card and the reference reading is obtained at the lubber line on the compass case as indicated on the marked compass scale. "Corrected compass" means "magnetic," which is given above.

*Relative.* The reference direction is the vehicle's heading, which is the forward direction along the vehicle's longitudinal center line. "Relative heading" and "relative course" should not be used. The proper terms are, respectively, "heading" and "drift angle."

*Grid.* The reference direction is the top of a grid which, for polar navigation, is a grid of rectangular coordinates superimposed over the polar regions. One line on this grid coincides with the Greenwich meridian. North on this grid is the direction upward on the chart, usually the direction of the North Pole from Greenwich.

## 3. DEFINITIONS OF TERMS

*ADF.* Automatic direction finder, specifically as used in aircraft.

*Aided Tracking.* A system of tracking a signal in bearing, elevation, or range, or any combination of these variables, in which a constant rate of motion of the tracking mechanism is maintained such that the motion of the target can be followed. The operator adjusts the rate by controlling an error parameter.

*Airborne Radar.* A radar set providing information in an aircraft about the relative position of fixed identification points or other aircraft.

*Air Position Indicator (API).* A dead reckoning com-

puter which integrates headings and speeds to give a continuous indication of position with respect to the air mass in which the vehicle is moving.

*Altitude.* Vertical distance above sea level.

*Ambiguity.* The condition obtaining when navigational co-ordinates define more than one point, direction, line of position, or surface of position.

*Angle of Elevation.* The angle measured at the observer between the horizontal plane and the line to the object.

*A-N Radio Range.* A navigational aid that establishes four radial equisignal zones, a deviation from the zones being indicated by the audible Morse Code letters A or N and the on-course indication being a continuous tone.

*Approach Navigation.* Navigation under such conditions that the approach to a dock or runway becomes of major importance.

*Approach Path.* That portion of the flight path in the immediate vicinity of the landing area where the flight path is ordinarily defined in three dimensions.

*A-Scope.* A cathode-ray indicator with a horizontal or vertical sweep, giving signal amplitude and distance. Signals appear as vertical or horizontal deflections on the time scale.

*Aural Radio Range.* A radio range facility whose courses are normally followed by interpretation of the transmitted aural signal.

*Automatic Tracking.* Tracking in which a servomechanism follows the signal automatically.

*Auto-Radar Plot.* See *Chart Comparison Unit.*

*Azimuth.* Same as true bearing and usually associated with celestial navigation.

*Azimuth-Stabilized PPI.* A PPI on which indicated north is fixed with respect to the heading of the vehicle, usually at the top of the screen.

*Baseline.* The geodesic between two stations that operate in conjunction for the determination of navigational co-ordinates.

*Bearing.* The angle in the horizontal plane between a reference direction and the line jointing the observer with an object, usually measured clockwise from the reference direction.

*B-Scope.* A cathode-ray indicator in which a signal appears as a spot with bearing as the horizontal co-ordinate and distance as the vertical co-ordinate.

*Boundary Marker.* A marker facility, in an instrument landing system, which is installed near the approach end of the landing runway and approximately on the localizer course line.

*Carrier Controlled Approach (CCA).* A radar system for aiding landing on aircraft carriers.

*Center Line.* The locus of the points equidistant from two reference points or lines.

*Chain.* A network of similar stations operating as a group for the determination of position.

*Challenge.* See *Interrogation.*

*Challenger.* See *Interrogator.*

*Chart Comparison Unit.* A device for positioning a radar map on a navigational chart.

*Coder.* See *Pulse Coder.*

*Coding Delay.* An arbitrary time delay in the transmission of pulse signals, usually inserted at a transmitting station.

*Compass Bearing.* The angle in the horizontal plane between the direction of magnetic north on the compass card and the line joining the observer and the object, usually measured clockwise.

*Compass Course.* The directng in the horizontal plane of intended travel with respect to the direction of magnetic north on the compass card, usually measured clockwise.

*Compass Heading.* The angle in the horizontal plane between the direction of magnetic north on the compass card and the line along which the vehicle is pointing, usually measured clockwise.

*Corner Reflector.* A reflecting object consisting of two or three mutually intersecting conducting surfaces. (Definition of Antennas Committee.)

Note: Corner reflectors may be dihedral or trihedral. Trihedral reflectors may be used as radar targets.

*Corrected Compass Course.* Same as *Magnetic Course.*

*Corrected Compass Heading.* Same as *Magnetic Heading.*

*Count Down.* The ratio of the number of interrogation pulses not answered to the total number of interrogation pulses in a transponder beacon.

*Course.* The direction of intended travel projected in the horizontal plane expressed as an angle from a reference direction, usually measured clockwise.

*Course Line.* The horizontal component of path of proposed travel for the vehicle. It comprises course and the element of distance.

*Course Error.* The angular difference between the planned course and the course made good by an aircraft.

*Course (Line) Computer.* The equipment which provides the means by which any arbitrary course line may be set up and flown, such as that used in connection with ODR and DME equipment.

*Course (Line) Deviation Indicator.* A cross-pointer instrument indicating deviation from a course line.

*Course Made Good.* The resultant direction the vehicle bears from a point of departure or waypoint, usually measured clockwise from true north.

*Course (Line) Selector.* An instrument providing means to select the course to be flown.

*Crossing Angle.* The angle at which two lines of position, or courses lines, intersect.

*C-Scope.* A cathode-ray indicator in which a signal appears as a spot with bearing as the horizontal co-ordinate and elevation angle as the vertical co-ordinate.

*Dead Reckoning.* Determination of position by advancing a known position through the addition of one

or more vectors representing known courses, times, and speeds.

*Decoder.* A circuit which responds to a particular coded signal and rejects others.

*Desired Track.* See *Path.*

*Destination.* The point of intended arrival.

*Differential Gain Control.* (Also called *Gain Time Control* or *Sensitivity Time Control.*) A device for altering the gain of a radio receiver at the times when various signals are expected, in order to reduce the discrepancy in amplitude between the signals at the output of the receiver.

*Directional Homing.* The procedure of following a path such that the objective is maintained at a constant relative bearing.

*Direction Finder* (*DF*). A radio aid to navigation that determines the direction of arrival of a radio signal by measuring the orientation of the wave front or of the magnetic or electric vector of a radio wave.

*Distance Measuring Equipment* (*DME*). A radio aid to navigation that determines the distance from a transponder beacon by measuring the total time of transmission to and from the beacon.

*Distance Mark.* A mark on a cathode-ray indicator which indicates the distance from a radar set to a target.

*Drift Angle.* The angular difference between the heading and the course made good.

*Electrical Distance.* The distance traveled by radio waves in a unit of time. A convenient unit of electrical distance is the light microsecond, or about 983 feet (300 meters). In this unit the electrical distance is numerically equal to the transmission time in microseconds.

*Elements of a Fix.* The specific values of the navigational co-ordinates necessary to define a position.

*Equiphase Zone.* The region in space within which the difference in phase of two radio signals is indistinguishable.

*Equisignal Zone.* The region in space within which the difference in amplitude of two radio signals (usually emitted by a single station) is indistinguishable.

*Fan Marker.* A vhf radio beacon, in an instrument landing system, having a fan-shaped radiation pattern and located along an airway radio range leg to provide a position fix.

*Fix.* Position determined without reference to any former position.

*Flag Alarm.* A semaphore-type flag provided in a navigational indicator to warn the pilot that a system failure has occurred.

*Flight-Path.* The path in space planned for an aircraft flight.

*Flight-Path Computer.* A computer including all of the functions of a course line computer and in addition providing means for controlling the altitude of the aircraft in accordance with any desired plan of flight.

*Flight-Path Deviation-Indicator.* An instrument providing an indication of deviation from flight path.

*Flight Track.* The track in space actually traced by an aircraft.

*Gain Time Control.* See *Differential Gain Control.*

*Geodesic.* The shortest line on the surface of the earth between two points.

*Glide Path.* See *Glide Slope.*

*Glide Slope.* (Previously called *Glide Path.*) An inclined surface of signal extending upward at an angle to the horizontal from the point of desired ground contact.

*Glide Slope Facility.* The means of providing a glide slope.

*Grid Bearing.* The angle, usually measured clockwise, between grid north and the initial direction of the arc of a great circle through an observer and a point.

*Grid Course.* A direction of intended travel projected in the horizontal plane expressed as an angle from grid north, usually measured clockwise.

*Grid Heading.* A direction in the horizontal plane expressed as an angle from Grid North to a line along which a vehicle is pointed, usually measured clockwise.

*Grid North.* An arbitrary reference direction used in connection with the Grid System of navigation. The reference direction is the top of a grid which, for polar navigation, is a grid of rectangular co-ordinates superimposed over the polar regions. One line on this grid coincides with the Greenwich Meridan. North of this grid is the direction upward on the chart, usually the direction of the North Pole from Greenwich.

*Ground Controlled Approach* (*GCA*). A ground radar system providing information by which aircraft approaches may be directed via radio communications.

*Ground Distance.* The horizontal component of distance from one object to another.

*Ground-Position Indicator* (*GPI*). A dead-reckoning tracer, similar to an air position indicator with provision for taking account of drift.

*Ground Surveillance Radar.* A radar set operated at a fixed point for observation and control of the position of aircraft or other vehicles in the vicinity.

*Heading.* The angle in the horizontal plane between a reference direction and the line along which the vehicle is pointing, usually measured clockwise.

*Homing.* Following a course directed toward a point by maintaining constant some navigational coordinates (other than altitude).

*Instrument Landing System* (*ILS*). A radio system which provides in the aircraft the directional, longitudinal, and vertical guidance necessary for landing.

*Interrogation.* Transmission of a radio-frequency pulse or combination of pulses intended to trigger a transponder or group of transponders.

Note: Sometimes called *Challenge.*

*Interrogator.* See *Interrogator-Responsor.*

*Interrogator-Responsor* (*IR*). A radio transmitter and receiver combined to interrogate a transponder and display the resulting replies.

Note: Sometimes called *Challenger.*

*Lattice.* A grid of identifiable lines of position laid

down in fixed positions with respect to the transmitters that establish it.

*Leader Cable.* A navigational aid consisting of a cable around which a magnetic field is established, marking the path to be followed.

*Line of Position.* A line along which two navigational co-ordinates are constant; known values of these co-ordinates establish the navigator's position as somewhere along this line.

*Localizer.* A radio facility which provides signals for lateral guidance of aircraft with respect to a runway center line.

*Long-Range Navigation.* Navigation at distances such that knowledge of position and objective alone are sufficient to permit determination of the proper course.

*Magnetic Bearing.* The angle in the horizontal plane between the direction of magnetic north and a line joining the observer and the object, usually measured clockwise.

*Magnetic Course.* The direction in the horizontal plane expressed as the angle of intended travel with respect to the direction of magnetic north.

*Magnetic Deviation.* Angular difference between compass reading and magnetic heading.

*Magnetic Heading.* The angle in the horizontal plane between the direction of magnetic north and the line along which the vehicle is pointing, usually measured clockwise.

*Marker.* In an instrument landing system, a radio facility providing a signal to designate a small area above it.

*Master Station.* The station of a synchronized group of stations that governs the emissions of the group.

*Matching.* In navigation, the process of bringing two quantities into suitable positions for measurement of their relative value.

*Middle Marker.* A marker facility which is installed approximately 3,500 feet from the approach end of the runway on the localizer course-line.

*Minimum Distance.* The shortest distance at which a navigational system will function.

*Moder.* See *Pulse Coder.*

*Moving Target Indicator (MTI).* A device which limits the display of radar information primarily to moving targets.

*Navigation.* The process of finding the position of a vehicle and directing it to reach a desired destination.

*Navigational Co-ordinate.* A quantity whose measurement serves to define a surface of position (or a line of position if one surface is already known) containing the vehicle.

*North-Stabilized PPI.* See *Azimuth-Stabilized PPI.*

*Offset-Course Computer.* An automatic computer which translates reference navigational co-ordinates into those required for a predetermined course.

*Omnibearing.* The bearing, usually magnetic, of an omnidirectional range station from a vehicle.

*Omnibearing Indicator.* An instrument providing automatic and continuous indication of the omnibearing.

*Omnibearing Converter.* An electromechanical device which combines the omnibearing signal with vehicle heading information to furnish electrical signals for the operation of the pointer of a radio magnetic indicator.

*Omnibearing-Distance Facility.* A radio facility, having an omnidirectional range in combination with distance-measuring equipment.

*Omnibearing-Distance Navigation (R-THETA).* Radio navigation utilizing a polar-coordinate system as a reference, making use of omnibearing-distance facilities.

*Omnibearing Selector.* An instrument capable of being set manually to any desired omnibearing, or reciprocal thereof, which controls a course line deviation indicator.

*Omnidistance.* The distance between the vehicle and an omnibearing-distance facility.

*Omnirange (or Omnidirectional Range).* A facility providing navigators with direct indication of the bearing of the omnirange facility from the vehicle.

*Outer Marker.* In an instrument landing system, a marker facility installed at approximately 5 miles from the approach end of the runway on the localizer course line.

*Path.* The proposed route of a vehicle in space. In surface navigation, the proposed route on the surface.

*Phase Localizer.* A localizer in which two signals are compared in phase to obtain lateral guidance.

*Pilotage.* Navigation without explicit determination of position, by directing a vehicle to its destination by observation of landmarks.

*Pitch Attitude.* The angle between the longitudinal axis of the vehicle and the horizontal.

*Polar Grid.* See *Grid.*

*Position.* The location of a vehicle as determined by specific values of three or more navigational co-ordinates.

*Plan Position Indicator (PPI).* A cathode-ray indicator in which a signal appears on a radial line. Distance is indicated radially and bearing as an angle.

*Pulse Coder.* A circuit which sets up a plurality of pulses disposed in an identifiable pattern.

*Pulse Interval.* The interval between the leading edges of successive pulses in a sequence characterized by uniform spacing; recurrence interval.

*Pulse Spacing.* The interval between the leading edges of successive pulses.

*Pulse Train.* A group of pulses of similar characteristics.

*Quadrantal Error.* Angular error of a measured bearing caused by disturbances due to the characteristics of the vehicle or station.

*Racon.* An abbreviation of "radar beacon"; a responder beacon for use with a radar set.

Note: See *Transponder.*

*Radar.* A device that measures the distance and direction of objects by reflection of radio waves.

*Radio-Autopilot Coupler.* Equipment providing means by which an electrical navigational signal will operate the automatic pilot to allow automatic flight.

*Radio Beacon.* A radio facility, usually a non-directional radio transmitter, providing signals for radio direction-finding observations.

*Radio Direction Finding.* Radiolocation in which only the direction of a station is determined by means of its emissions.

*Radiolocation.* Determination of a position or of a direction by means of the constant velocity or rectilinear propagation properties of the Hertzian waves.

*Radio Magnetic Indicator (RMI).* An instrument which presents a combined display of vehicle heading, relative and magnetic bearings, and omnibearings of the radio station being utilized for navigation purposes.

*Radio Navigation.* Navigation by means of radio signals.

*Radio-Range.* A radio facility providing radial equisignal zones.

*Range.* See *Operating Distance*, and *Radio Range.*

*Range Mark.* See *Distance Mark.*

*Recurrence Rate.* See *Repetition Rate.*

*Reference Direction.* The direction used as a reference for angular measurements.

*Reference Line.* A line passing through a reference point and an observer.

*Relative Bearing.* The angle, usually measured clockwise, between the heading of a vehicle and the initial direction of the arc of a great circle through an observer and a point.

*Relative Course.* See *Drift Angle.*

*Relative Heading.* The heading itself. "Relative" is superfluous.

*Repetition Rate.* The rate at which recurrent signals are transmitted.

*Reply.* A radio-frequency pulse or a combination of pulses transmitted by a transponder as a result of an interrogation.

*Resolution.* The degree to which nearly equal values of a quantity can be discriminated.

*Responder Beacon.* See *Transponder.*

*Responder.* A receiver in a transponder whose function is to receive the signals transmitted from a beacon.

*Scanning.* A periodic motion given to the major lobe of an antenna.

Note: Definition of Antennas Committee.

*Searchlighting.* Projecting the radar beam continuously at an object instead of scanning.

*Sensing.* The relative direction of motion of a deviation indicator needle resulting from departure of a vehicle from the desired flight path.

*Service Area.* The area within which a navigation aid is of use.

*Short Distance Navigation.* Navigation which is predicated upon aids spaced less than 200 miles apart.

*Slant Distance.* The distance from an object to another object not at its own elevation. Used in contrast to ground range.

*Slave Station.* A station of a synchronized group whose emissions are controlled by a master station.

*Slope.* The projection of a flight path in the vertical plane.

*Slope Angle.* The direction of a flight path expressed as an angle projected on the vertical plane.

*Slope Deviation.* The difference between the projecion in the vertical plane of the actual path of movement of a vehicle and the planned slope for the vehicle expressed in terms of either angular or linear measurement.

*Sonar.* The general name for sonic and/or ultrasonic underwater echo-ranging and echo-sounding systems.

*Stable Element.* A gyroscopic instrument which maintains a true vertical and shows angles of deviation of the ship's deck or aircraft's axis from the true horizontal.

*Stabilization.* A system for maintaining a device in a desired direction in space despite the motions of the ship or aircraft.

*Star Chain.* A group of navigational radio transmitting stations in Y form with the master facility in the center and three (or more) slave facilities around the circumference of a rough circle.

*Surface of Position.* A surface that is defined by a constant value of some navigational coordinate.

*Terrain Clearance Indicator* (Sometimes called *Absolute Altimeter*). A device measuring the distance from an aircraft to the surface of the sea or ground.

*Tilt.* The angle which an antenna axis forms with the horizontal.

*Time Gain Control.* See *Differential Gain Control.*

*To-From Indicator.* An instrument to show whether the numerical reading of an Omnibearing Selector for an "on course" indication of the omnibearing indicator represents the bearing toward or away from a vhf omnirange.

*Tone Localizer.* A localizer which transmits two modulation frequencies for amplitude comparison.

*Track.* The projection on the earth's surface of the actual path followed by a vehicle.

*Tracking.* The process of keeping radar beams or the cross hairs of an optical system set on a target.

*Track Homing.* The process of following a line of position known to pass through an objective.

*Transponder.* A transmitter-receiver facility whose function is automatically to transmit signals when the proper interrogation is received.

*Transponder-Beacon.* See *Transponder.*

*Triplet.* Three radio facilities operated as a group for the determination of positions.

*True Bearing.* The angle measured clockwise between true north and the initial direction of an arc of a great circle through an observer and a point.

*True Course.* A direction of intended travel projected in the horizontal plane expressed as an angle measured clockwise from true north.

*True Heading.* A direction in the horizontal plane expressed as an angle measured clockwise from true north to a line along which a vehicle is pointed.

*True Homing.* The process of following a course such

that the true bearing of a vehicle as seen from an objective is held constant.

*Variation.* The angular difference between true and magnetic bearings.

*VHF Omnirange.* A vhf radio navigation station providing direct indication of the magnetic bearing (omnibearing) of that station from a vehicle.

*Visual-Aural Radio Range.* A radio range which provides aural sector identification and visual course indication. The visual course of this range defines the primary navigation course and is flown by visual means. The aural sector identification results in an aural course at 90° to the visual course.

*Visual Radio Range.* Any range facility the course of which is flown by visual instrumentation not associated with aural reception.

*Way-Point.* A course line point the co-ordinates of which are defined in relation to established radio navigation aids.

*Zone (Z) Marker.* A vhf radio facility located at airways radio range stations to indicate position above such ranges.

## 4. SUPPLEMENTARY DEFINITIONS

The following supplementary list offers brief descriptions of a number of navigation aids known chiefly by recently adopted names that are not yet universally recognized. The definitions are recorded for information but not for standardization.

*Babs.* Blind Approach Beacon System. A pulse-type ground-based navigation beacon used for runway approach at airfields.

*Benito.* A continuous wave navigation system measuring range and azimuth from one or more ground stations. The range is determined by a phase comparison method.

*Consol.* British code word for *Sonne.*

*Decca.* A continuous wave differential distance hyperbolic radio aid to navigation in which the receiver measures and integrates the relative phase difference between the signals received from two or more synchronized ground stations.

*Electra.* A German continuous wave navigation system using radio beacons providing multilobe equisignal patterns.

*Eureka.* The ground radar beacon of the Rebecca-Eureka navigation system.

*GCI.* Ground Controlled Interception. A radar system by means of which a controller at the radar may direct an aircraft to make an interception of another aircraft.

*Gee.* A medium range hyperbolic radio aid to navigation whose position lines are determined by measuring the difference in time of arrival of synchronized pulsed signals.

*Gee H.* A combination of the *Gee* and *H* systems of navigation.

*H.* A radar air navigation system using an airborne interrogator to measure distance from two ground responder beacons.

Note: See *Shoran.*

*Lanac.* Laminar Navigation Anti-Collision. This system consists of air and ground radar and beacon equipments with height coding of the aircraft transmitter pulses.

*Loran.* A long range pulsed hyperbolic radio aid to navigation whose position lines are determined by the measurement of the difference in the time of arrival of synchronized pulses.

*MEW.* Microwave Early Warning. A high power long-range, 10-centimeter early warning radar with a number of indicators, giving high resolution and large handling capacity.

*Navar.* A co-ordinated series of radar air navigation and traffic control aids including both air and ground equipments.

*Navaglobe.* A long range continuous wave lf navigation system of the amplitude comparison type.

*Oboe.* A radar navigation system consisting of two ground stations measuring distance to an airborne responder beacon and relaying information to the aircraft.

*POPI.* Post Office Position Indicator. A continuous wave lf navigation system of the phase comparison type.

*Rebecca.* The airborne interrogator responder of Rebecca-Eureka, a radar responder beacon system.

*SBA.* Standard Beam Approach. A continuous wave approach system using a localizer and markers.

*Shoran.* Short Range Navigation. A precision position fixing system using a pulse transmitter and receiver and two transponder beacons at fixed points.

*Sonne.* A radio aid to navigation that provides a number of equisignal zones which rotate in a time sequence so that a navigator may determine his true bearing from the transmitter by observation of the instant at which he hears the equisignal.

*Teleran.* Television and radar navigation system. Television image of ground PPI and map and weather data are presented in the aircraft.

*Tricon.* A radar system in which the receiver records the coincidence of received pulses from a group of three ground stations pulsed in variable time sequence.

*VOR.* Vhf phase comparison omnidirectional radio range system developed by the Civil Aeronautics Administration.

# Standards on RAILROAD AND VEHICULAR COMMUNICATIONS: METHODS OF TESTING, 1949*

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# 1. INTRODUCTION

These Standards cover definitions of terms and methods of testing communication receivers designed to receive frequency-modulated (FM) waves in the frequency range from 25 to 225 megacycles. In view of the several bands presently allocated for communications services in this range and the possibility that these bands may be modified from time to time, carrier-frequency limits for the individual sub-bands are not specified.

# 2. DEFINITIONS OF TERMS

## 2.1. Test Frequencies

In general, the test frequencies for the various designated sub-bands consist of one frequency near the lower edge of the sub-band, one near the upper edge, and one near the center. When measurements are to be made at a single frequency only, that frequency should be chosen near the center of the sub-band unless the equipment is designated for a specific frequency, in which case its specified operating frequency should be used.

## 2.2. Test Input Signals

Input-signal intensities may be expressed in either of two ways:

(a) In terms of available power, in which case the input is expressed in decibels below 1 watt.

(b) In terms of input voltage, in which case the input is expressed in microvolts with the input impedance specified.

## 2.3. Available Power

The available power is the power delivered by a generator to a matched load. It is equal to $E^2/4R$ where $E$ is the open-circuit voltage of the generator and $R$ is the internal resistance of the generator plus the dummy-antenna resistance. It is expressed in decibels below 1 watt. A signal generator may be calibrated in terms of the available signal power and used on that basis though not matched exactly by the load impedance. If a signal generator is to be used with various values of dummy-antenna resistance, it should be calibrated in terms of the open-circuit voltage, and the available power should be calculated from the above formula. In this report, when values of power input are spoken of, it should be understood that the available power is meant.

## 2.4. Standard Input Values

Five values of standard input are specified for the purpose of certain tests. The values of standard input voltage are equivalent to the corresponding values of standard input power for receivers designed for input impedances of 50 and 70 ohms.

### *2.4.1. Standard Mean-Signal Input*

The standard mean-signal input is either 123 decibels below 1 watt or the equivalent signal measured in microvolts (10 microvolts at 50 ohms, 12 microvolts at 70 ohms).

TABLE I

| (a) Standard Input Powers, decibels below 1 watt | (b) Standard Input Voltages in Microvolts (Open Circuit) | |
|---|---|---|
| | 50 ohms input impedance | 70 ohms input impedance |
| 143 | 1 | 1.2 |
| 123 | 10 | 12 |
| 83 | 1,000 | 1,200 |
| 43 | 100,000 | 120,000 |
| 23 | 1 volt | 1.2 volts |

## 2.5. Standard Test Modulation

Standard test modulation in tests on frequency-modulation communication receivers refers to a signal that is frequency-modulated at 1,000 cycles with a deviation of 70 per cent of maximum rated system deviation. In this report, maximum rated system deviation is taken as 15 kilocycles, so that the deviation due to standard test modulation is 10.5 kilocycles.

## 2.6. Usable-Sensitivity Test Input

The usable-sensitivity test input is the least input signal of a specified carrier frequency having standard test modulation which, when applied to the receiver through the standard dummy antenna, results in standard test output with the ratio of the root sum square, signal+noise+distortion, to the root sum square, noise+distortion, equal to at least 12 decibels. This test discloses the influence of the selective circuit of the receiver and of internal receiver noise on the usable sensitivity of the receiver.

## 2.7. Deviation-Sensitivity Test Input

The deviation-sensitivity test input is the minimum deviation at 1,000 cycles of a carrier wave of standard mean-signal input value (Section 2.4.1) required to give standard test output (Section 2.9) when all controls are adjusted for greatest sensitivity. The deviation sensitivity is expressed in kilocycles or as a percentage of maximum rated system deviation.

## 2.8. Quieting-Signal-Sensitivity Test Input

The quieting-signal-sensitivity test input is the least unmodulated signal input which, when applied to the

receiver through the standard dummy antenna, reduces the receiver noise output by a factor of 20 decibels. It is expressed in dedibels below 1 watt or in microvolts with input impedance specified.

**Note.** This is not the same characteristic as that described in Section 2.09 of *Standards on Radio Receivers: Methods of Testing Frequency-Modulation Broadcast Receivers, 1947*, which has the same title. It is believed that the above test is more applicable to communication receivers and more easily made with available field test equipment.

### 2.9. Standard Test Output

Standard Test output is equal to one-half of the rated power output of the receiver.

### 2.10. Rated Power Output

The rated power output is as specified by the manufacturer.

### 2.11. Standard Dummy Antenna

The standard dummy antenna comprises a resistor connected in series with the high terminal of the signal generator, of such value that the total impedance presented to the receiver is equal to the rated receiver input impedance. It is intended to simulate the mean value of the impedance of a typical transmission line connected to an antenna. (See Fig. 1.)

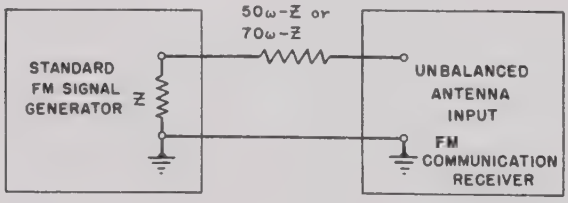


Fig. 1—Standard communication dummy antenna and method of connection.

### 2.12. Standard Pre-Emphasis Characteristic

The standard pre-emphasis characteristic has a rising response, with modulated frequency, of 6 decibels per octave. This is the characteristic obtained by linear phase modulation.

### 2.13. Standard De-Emphasis Characteristic

The standard de-emphasis characteristic has a falling response with modulating frequency, the inverse of the standard pre-emphasis characteristic or 6 decibels per octave. This characteristic may be approached over the usable audio-frequency range by taking the voltage across the capacitor when a capacitor and a resistor are connected in series and fed from a constant-voltage source. Deemphasis is usually incorporated in the audio circuits of the receiver.

### 2.14. Frequency Deviation

Frequency deviation, in frequency modulation, is the peak difference between the instantaneous frequency of the modulated wave and the carrier frequency.

### 2.15. Maximum System Deviation

Maximum system deviation is the greatest deviation specified in the operation of the system. The maximum system deviation is usually 15 kilocycles.

### 2.16. Selectivity

Selectivity is the extent to which a receiver is capable of differentiating between the desired signal and disturbances of other frequencies.

### 2.17. Spurious Response

Spurious response is receiver response which exists because of other than all desired normal frequency translations in the receiver.

### 2.18. Squelch

Squelch is a means whereby a receiver is prevented from producing audio frequency output in the absence of a signal having predetermined characteristics. A squelch circuit may be operated by signal energy in the receiver pass band, by noise quieting, or by a combination of the two (ratio squelch). It may also be operated by a signal having special modulation characteristics (selective squelch).

## 3. REQUIREMENTS AND CHARACTERISTICS OF TESTING APPARATUS

### 3.1. Signal Generator

A frequency-modulated signal generator is required for testing frequency-modulation radio receivers.

The signal generator should cover at least the carrier-frequency ranges of the various sub-bands being considered. It preferably should also cover the intermediate-frequency ranges and frequency ranges required for spurious-response tests.

Single-ended output terminals should be provided. These terminals should be on the end of a flexible cable.

The output meter of the signal generator should indicate the open-circuit voltage at the terminals, and the internal impedance should be stated.

The generator should be capable of being frequency modulated at rates from 300 to at least 3,000 cycles per second, and at deviations from zero to at least rated system deviation and preferable to twice that value. It should be provided with a deviation indicator reading from zero up to the maximum deviation.

The modulation circuit of the generator should be

provided with a pre-emphasis network providing 6 decibels per octave pre-emphasis over the audio-frequency range of 300 to 3,000 cycles. A switch should be provided for cutting this pre-emphasis network in or out of the generator circuit at will.

The generator syould provide a frequency-modulated signal at 400 and at 1,000 cycles up to maximum rated system deviation with less than 2 per cent root-sum-square distortion. Amplitude modulation resulting from the frequency modulation should be kept to a minimum.

The frequency and amplitude modulation of the output voltage due to power-supply ripple should be negligible, in comparison with the effects under observation.

### 3.2. Audio-Output and Distortion-Measuring Devices

Apparatus for the measurement of distortion, required for Sections 4.1 and 4.2, should consist of distortion meter of the type which integrates the total noise and distortion, while balancing or filtering out the fundamental frequency of the audio signal.

### 3.3. Standard-Signal Generator for Two-Signal Test

For certain tests of radio communications receivers, two radio-frequency input signals are required simultaneously, and consequently two standard-signal generators are employed. The recommended method is to use a dummy antenna on each signal generator of twice the standard dummy antenna resistance. The terminals of the two-dummy antennas are then connected in parallel and to the input terminals of the receiver. By this arrangement, the impedance connected across the receiver input terminals is the normal value, and the open-circuit signal voltages are half the values indicated by each generator.

## 4. TEST PROCEDURES

### 4.1. Usable-Sensitivity

A calibrated signal generator is connected to the input of the receiver under test through a standard dummy antenna (Section 2.11). The signal generator is adjusted to the receiver frequency, and standard test modulation (Section 2.5) is applied. A distortion meter of the type which integrates the total noise and distortion while balancing or filtering out the 1,000-cycle fundamental frequency of the signal is connected to the output of the audio-amplifier.

The signal generator output is adjusted to the minimum signal which will provide standard test output from the receiver. The signal+noise+distortion to noise +distortion ratio is then measured, and, unless found to be 12 decibels or more, the signal is increased, holding the receiver audio output constant at standard test output by means of the receiver audio gain control, until this value is obtained. The signal required to produce this result is the usable sensitivity. Measurements should be made at each of the test frequencies (Section 2.1).

### 4.2. Two-Signal Selectivity

Two signal generators of similar characteristics shall be equally coupled to the input of the receiver in such a fashion that they do not react upon one another, and in combination present an impedance match to the input circuit. Both signal generators shall be modulated equally at 70 per cent of maximum system deviation (Section 2.15), with signal generator No. 1 at 1,000 cycles and signal generator No. 2 at 400 cycles.

With the output of No. 2 at zero, No. 1 shall be set to the receiver frequency and its output adjusted until the receiver input equals that impressed on its terminals when one of the standard input values (Section 2.4) is applied through the standard dummy antenna (Section 2.11).

Signal generator No. 2 shall then be set at a frequency differing from No. 1 and its output increased until the signal+noise+distortion to noise+distortion ratio decreases to 6 decibels. During this measurement the modulation products from signal generator No. 2 are to be considered as noise.

The selectivity of the receiver at the frequency between the two signal generators is then specified by the ratio of their radio-frequency output amplitudes.

If the total audio output of the receiver drops by 6 decibels at a smaller radio-frequency ratio than that referred to above, the selectivity is specified by the ratio of radio-frequency amplitudes when this occurs.

The selectivity characteristic of a receiver may be displayed by a plotted curve showing the variation of radio-frequency amplitude ratio, plotted in decibels as the ordinate, with frequency differences as the abscissa. Both scales should be linear.

These same data should be obtained with desired signal values corresponding to each of the standard input values (Section 2.4) within the limitations of the measuring equipment.

### 4.3. Spurious Response

The desired-signal input values are the same as used in the selectivity measurements, and the interfering input voltage is referred to the desired-signal input. Proceed as in the measurement of two-signal selectivity, except that the interfering signal is tuned to produce peak response for the spurious mode under test. The spurious response of the receiver at the given interference and test frequencies is specified by the ratio of the radio-frequency output amplitudes of the two-signal generators.

# TESTS FOR EFFECTS OF MISTUNING AND FOR DOWNWARD MODULATION, 1949*

## Supplement to Standards on

# RADIO RECEIVERS: METHODS OF TESTING FREQUENCY-MODULATION BROADCAST RECEIVERS, 1947

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## 1. MISTUNING

1.1. The degree of mistuning is represented by the total signal output distortion resulting when the receiver is adjusted to a frequency other than the desired signal frequency. The measurement is made by setting the signal generator to standard input voltages successively, modulating the signal generator to 75 kc deviation at standard test output. The signal generator is then adjusted off tune by successive increments, the volume control is adjusted for standard test output, and the total distortion in per cent (or db) is measured. For each value of input signal a curve is plotted, having as abscissa the frequency difference of detuning, and as ordinate the distortion expressed in per cent, or db. Distortion components will comprise all frequencies present except the fundamental frequency of the modulating tone. In these tests the signal generator is adjusted off tune on each side of the signal frequency.

1.2. The standard measurement will comprise setting the signal generator on each side of the signal frequency and noting the amount of mistuning that will produce 10 per cent distortion, expressing the degree of mistuning as the average of the measured plus and minus frequency excursions. The signal input for this test shall be the standard mean signal input (1,100 microvolts).

This mistuning test should be correlated with the frequency drift test, Sec. 4.05.20.

## 2. DOWNWARD MODULATION

2.1. This test will define the ability of the receiver to withstand the effects of downward amplitude modulation. In this test it is assumed that the principal forms of distortion are caused by the downward component of modulation.

2.2. The test is made at the standard mean-carrier frequency (98 megacycles). Frequency modulation is impressed at a 400-cycle modulation rate at 30 per cent of maximum rated system deviation and the volume control is adjusted for standard output. The input signal is then simultaneously amplitude modulated at a 100-cycle rate. By means of a band cut-off filter, the 100-cycle modulation is eliminated in the receiver output. The amplitude modulation is then increased until the total distortion reaches 10 per cent. The percentage modulation at this point is the downward modulation capability of the receiver. The test is made at all values of standard input signal voltages.

# Standards on PIEZOELECTRIC CRYSTALS, 1949*

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## INTRODUCTION

In 1945 a report entitled "Standards on Piezoelectric Crystals: Recommended Terminology" was prepared by the Committee on Piezoelectric Crystals and issued by the Institute. The present report involves not only much new material, but also a revision of certain portions of the earlier report.

Part I of the 1945 report (corresponding to Part 1 of this Standard) remains unchanged, with the following exceptions: The use of left-handed axes for left crystals is now abandoned (see Sections 1.9, and 1.11 to 1.14); and the 1945 rules for rotated plates are now supplanted by the rules in the present report.

In Part II (corresponding to Part 2 of this Standard), Sections 11 and 13 have been revised. Otherwise, Part II remains in effect. The introduction of new crystals, some belonging to classes for which no satisfactory conventions have existed, makes desirable a self-consistent set of conventions, sufficiently comprehensive to include all piezoelectric crystal classes. This necessitates certain changes in the definitions of the axes of quartz and in the algebraic signs of piezoelectric and elastic constants, as described in Sections 1.12 to 1.14. These changes result not only in agreement with the crystallographers, but, fortunately, in better conformity with shop practice as it has developed.

Part 3 of the new Standard presents basic equations, symbols, and units of piezoelectric theory. It has been prepared in view of the growing tendency to express

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elastic stress and strain as dependent upon the electric displacement, rather than upon the electric field, and also in view of the increasing use of mks units. The formulation in terms of displacement is especially useful in cases where there is a gap between crystal and electrodes, also in dealing with crystals whose constants show a marked dependence on temperature. In the latter case it is found that the "constants" have more nearly constant values when expressed in terms of displacement than in terms of field.

When there is no gap between crystal and electrodes it is often found more convenient to use Voigt's formulation, with the piezoelectric constants expressed in terms of electric field strength rather than displacement.

The equations are interconvertible. The Voigt piezoelectric constants $d$ and $e$ are related to the more recent constants $g$ and $h$ by the dielectric constant. For some purposes it is convenient to use expressions involving combinations of constants from both formulations. In doing so it is necessary, of course, to use the same system of units, esu or mks.

### Authorship and Acknowledgment

This Standard is the result of several years of conferences involving all of the members of the Committee. Its form and its completeness, which in effect make it an introduction to the formal treatment of piezoelectricity, come from the fact that it is basically a collection of several papers prepared for the Committee by individual members and their collaborators serving as subcommittees. There would have been entire justification for the separate publication of these papers by their individual authors, but it has been the view of the Committee that the advantages of unification into a system such as the Standard is intended to establish could best be gained by bringing all papers into a common publication with agreement as to symbols, conventions, and equations.

The authorship of the several parts of the Standard is as follows: Part 1 is an elaboration of memoranda prepared for the Committee by W. L. Bond, entitled "Crystal Axis Nomenclature," October 25, 1946, and "Axes For Triclinic Crystals," June 16, 1947. Part 2 stems from a memorandum by W. L. Bond of August 19, 1946, on "Crystal Rotation Systems." Part 3 is an expansion of a memorandum by Paul L. Smith, "The Piezoelectric Relations, Symbols and Units," June 3, 1946, in which he had the collaboration of H. G. Baerwald of the Brush Development Company. The adopted formulation of the theory is based on equations first presented by the latter in a wartime report[1] to the NDRC.

[1] H. G. Baerwald, OSRD Report No. 287, Contract No. OEMsr-120, 1941.

## 1. Definitions of Axes for Piezoelectric Crystals

### 1.1 Crystals and Their Classification

For the guidance of those who are not familiar with crystallography, the following summary of those principles to which reference will be made later in this Standard may be helpful.

The term "crystal" is usually applied to solids that possess structural symmetry. In a crystal the atoms may be thought of as occurring in small groups, all groups exactly alike, similarly oriented, and regularly aligned in all three dimensions. If each group is regarded as bounded by a parallelepiped, the latter can be looked upon as one of the ultimate building blocks of the crystal; they are stacked together in all three dimensions without any spaces between. Such a building block is called a *unit cell*. Since the choice of the particular set of atoms to form a unit cell is arbitrary, it is evident that there is a wide range of choice in the shape and dimensions of the unit cell. In practice, that unit cell is selected which is most simply related to the actual crystal faces and X-ray reflections, and which has the symmetry of the crystal itself. Except in a few special cases the unit cell has the smallest possible size.

Depending on their degrees of symmetry, crystals are commonly classified in seven *systems:* triclinic (the least symmetrical), monoclinic, orthorhombic, tetragonal, hexagonal, trigonal, and isometric. Some authorities, however, treat trigonal crystals as a division of the hexagonal system.

The seven systems in turn are divided into point-groups (classes) according to their symmetry with respect to a point. There are thirty-two such classes, of which twelve are of too high a degree of symmetry to show piezoelectric properties. Thus twenty classes can be piezoelectric. Every system contains at least one piezoelectric class.

### 1.2. General

In determining a suitable nomenclature for the many new crystals that are finding their way into the piezoelectric field, it seems wise to make use of the nomenclature of the highly developed science of crystallography. This facilitates the use of data already recorded by crystallographers. Such data are, for example, atomic cell dimensions and angles, optical properties, and interfacial angles, all of which can be useful for establishing orientations of piezoelectric plates. In crystallography, the properties of a crystal are described in terms of the natural co-ordinate system provided by the crystal itself. The axes of this natural system are the edges of the unit cell. In a cubic crystal these axes are of equal length and are mutually perpendicular; in a triclinic crystal they are of unequal lengths and no two are mutually perpendicular.

The faces of any crystal are all parallel to planes whose intercepts on the natural axes $a$, $b$, $c$ are small multiples of unit distances or else infinity, so that their reciprocals, when multiplied by a small common factor, are all small integers or zero. These are the indices of the planes. In this nomenclature we have, for example, faces (100), (010), (001), also called the a, b, c faces, respectively; in the orthorhombic, tetragonal, and isometric systems these faces are normal to the $a$, $b$, $c$ axes. Other examples are faces (111) (the unit face), (121), etc. As referred to a set of rectangular axes $X$, $Y$, $Z$, these indices will in general be irrational except for cubic crystals.

On the other hand, the theoretical treatment of electricity and elasticity, which is fundamental in piezoelectric applications, has been developed with rectangular axes. One must therefore adopt some arbitrary relation between the $a$, $b$, $c$ axes of crystallography and the rectangular $X$, $Y$, $Z$ axes. Unless all workers in the field agree to use the same nomenclature, there will be great confusion. Data expressed in terms of one $abc$-$XYZ$ relation look very different from the same data in terms of another $abc$-$XYZ$ relation.

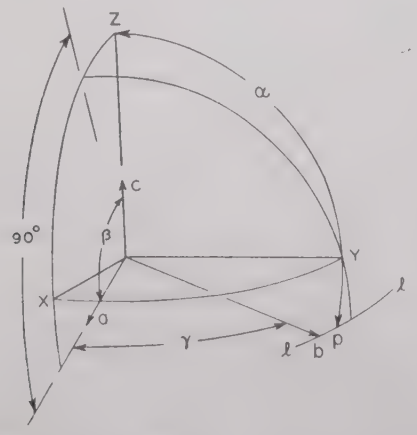


Fig. 1—Axes of triclinic crystals.
The line $l$–$l$ is on a small circle with pole $Z$ and angle $\alpha$. For $b$ to left of $p$, $\gamma<90°$. For $b$ to right of $p$, $\gamma>90°$.

### 1.3. The Triclinic System

If there are neither symmetry axes nor symmetry planes present in a crystal, it is triclinic. The lengths of the three axes are in general unequal, and the angles $\alpha$, $\beta$, and $\gamma$ are also unequal. $\alpha$, $\beta$, $\gamma$ are the angles between $b$ and $c$, $c$ and $a$, and $a$ and $b$, respectively, as shown in Fig. 1. Fig. 2, a triclinic crystal, shows that

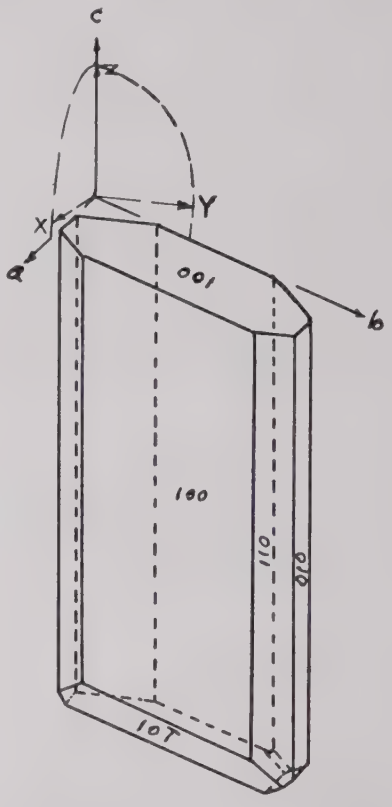


Fig. 2—Aminoethyl ethanolamine hydrogen $d$-tartrate, triclinic, class 1.
The $Z$ axis is along $c$, $Y$ normal to (010), $X$ perpendicular to $Y$ and $Z$.

the $a$ axis has the direction of the intersection of the faces b and c (extend the faces to intersection if necessary), the $b$ axis has the direction of the intersection of faces c and a, the $c$ axis has the direction of the intersection of faces a and b. According to the best current usage the positive directions of $a$, $b$, and $c$ are taken so as to make $\alpha$ greater than 90°, and $\beta$ also greater than 90°. This convention determines uniquely the positive senses of all axes. (Many old works record the complementary angle, i.e., the angle between $-a$ and $+c$ as $\beta$.) The $a$, $b$, and $c$ axes are in general to be chosen as the three shortest noncoplanar interatomic distances, with $c$ the shortest unit distance, $b$ the longest.

#### *1.3.1. The X, Y, Z axes*

The most logical relation is that which associates the $X$, $Y$, $Z$ axes most closely with the $a$, $b$, $c$ axes, respec-

tively. There are six equally simple ways of completing the specification: $X$ along $a$ and $Y$ in the $ab$ plane; $X$ along $a$ and $Z$ in the $ac$ plane; $Y$ along $b$ and $X$ in the $ab$ plane; $Y$ along $b$ and $Z$ in the $bc$ plane; $Z$ along $c$ and $Y$ in the $bc$ plane; or $Z$ along $c$ and $X$ in the $ac$ plane. In physics and technology $Z$ is commonly pictured as the vertical axis, while in crystallography $c$ is usually so pictured. Hence we take $Z$ along $c$ and have only the choice of $Y$ in the $bc$ plane or $X$ in the $ac$ plane. The choice now accepted is to let $Y$ be normal to the $ac$ plane; this automatically places $X$ in the $ac$ plane.

The rules for the rectangular axes, together with their positive directions, are summarized as follows (see Figs. 1 and 2):

$+Z$ is parallel to $+c$, hence parallel to the (100) and (010) planes.

$+X$ is perpendicular to $c$ in the $ac$ plane, pointing in the general direction of $+a$. $X$ is thus parallel to (010).

$+Y$ is normal to the $ac$ plane (010), pointing in the general direction of $+b$, and forming a right-handed axial system with $Z$ and $X$.

### 1.4. The Monoclinic System

If a crystal has but a single axis of twofold symmetry, or but a single plane of reflection symmetry, or both, it belongs to the monoclinic system. Either the twofold axis or the normal to the plane of symmetry (they are the same if both exist, and this direction is called the unique axis in any case) is taken as the $b$ axis. Of the two remaining axes, modern crystallographers always make $c$ the smaller. The angle $\beta$ between $+a$ and $+c$ is always obtuse (a special convention has to be adopted when this angle is obtuse at some temperatures, acute at others). This convention determines uniquely the positive directions of all axes for classes 2 and $2/m$. In class $m$ there are two alternatives. The choice between them is indicated in Section 1.16. Since the axes chosen by early workers may not give the smallest possible cell, a new cell with a smaller volume can be chosen.

Many physicists seem to prefer to make $Z$ the unique axis of monclinic crystals. This is the convention adopted by Voigt, and continued by Cady in his book "Piezoelectricity."[2] Nevertheless, in most crystallographic literature $b$ is taken as the unique axis in the monoclinic system. Henceforth "$Z$ along $c$, $Y$ along $b$" is to be the standard $abc$-$XYZ$ relation for monoclinic crystals, as illustrated in Fig. 3. According to this convention, with the unique axis $b$ taken as the $Y$ axis, the stresses $T$ and strains $S$ are related through the matrix equations $S=sT$ and $T=cS$, where the compliance constant $s$ takes the form[3]

$$s = \begin{vmatrix} s_{11} & s_{12} & s_{13} & 0 & s_{15} & 0 \\ s_{12} & s_{22} & s_{23} & 0 & s_{25} & 0 \\ s_{13} & s_{23} & s_{33} & 0 & s_{35} & 0 \\ 0 & 0 & 0 & s_{44} & 0 & s_{46} \\ s_{15} & s_{25} & s_{35} & 0 & s_{55} & 0 \\ 0 & 0 & 0 & s_{46} & 0 & s_{66} \end{vmatrix} \tag{1}$$

The stiffness constant $c$ takes an analogous form. Also, electric displacement and elastic stress are related through the matrix equation $D=dT$, where the piezoelectric strain-constant $d$ takes the form, for class 2 ($Y$ a twofold axis),

$$d = \begin{vmatrix} 0 & 0 & 0 & d_{14} & 0 & d_{16} \\ d_{21} & d_{22} & d_{23} & 0 & d_{25} & 0 \\ 0 & 0 & 0 & d_{34} & 0 & d_{36} \end{vmatrix} \tag{2}$$

while for class $m$ (a plane of reflection-symmetry perpendicular to $Y$)

$$d = \begin{vmatrix} d_{11} & d_{12} & d_{13} & 0 & d_{15} & 0 \\ 0 & 0 & 0 & d_{24} & 0 & d_{26} \\ d_{31} & d_{32} & d_{33} & 0 & d_{35} & 0 \end{vmatrix}. \tag{3}$$

The matrices (1), (2), and (3) replace those that have hitherto been in common use according to Voigt's convention. To each elastic or piezoelectric constant on the new convention there corresponds one on the old, with the same numerical value.

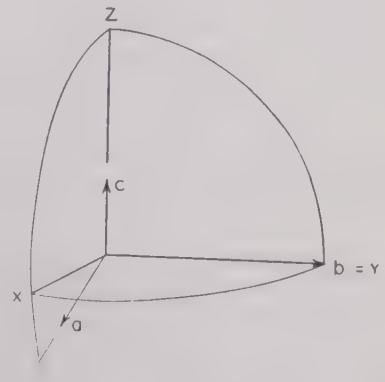


Fig. 3—Axes of monoclinic crystals.
$a$ and $c$ are perpendicular to $b$ but not to each other.

For comparison with the new matrices (1), (2), and (3), the corresponding expressions according to Voigt's

[2] W. G. Cady, "Piezoelectricity," McGraw-Hill Book Co., New York, N. Y., 1946.

[3] See part 3 of this Standard.

convention will now be given. The Voigt matrix for elastic compliance, now abandoned, is

$$s = \begin{vmatrix} s_{11} & s_{12} & s_{13} & 0 & 0 & s_{16} \\ s_{12} & s_{22} & s_{23} & 0 & 0 & s_{26} \\ s_{13} & s_{23} & s_{33} & 0 & 0 & s_{36} \\ 0 & 0 & 0 & s_{44} & s_{45} & 0 \\ 0 & 0 & 0 & s_{45} & s_{55} & 0 \\ s_{16} & s_{26} & s_{36} & 0 & 0 & s_{66} \end{vmatrix} \tag{4}$$

with an analogous form for $c$.

For class 2, the Voigt matrix (in which $Z$ is a twofold axis), now abandoned, is

$$d = \begin{vmatrix} 0 & 0 & 0 & d_{14} & d_{15} & 0 \\ 0 & 0 & 0 & d_{24} & d_{25} & 0 \\ d_{31} & d_{32} & d_{33} & 0 & 0 & d_{36} \end{vmatrix}, \tag{5}$$

while for class $m$ (reflection-plane perpendicular to $Z$) the Voigt matrix, now abandoned, is

$$d = \begin{vmatrix} d_{11} & d_{12} & d_{13} & 0 & 0 & d_{16} \\ d_{21} & d_{22} & d_{23} & 0 & 0 & d_{26} \\ 0 & 0 & 0 & d_{34} & d_{35} & 0 \end{vmatrix}. \tag{6}$$

If we know the $s$ and $d$ matrices for Voigt's convention, we can put them in standard form by means of the following matrices:

$$s = \begin{vmatrix} s_{22}' & s_{23}' & s_{12}' & 0 & s_{26}' & 0 \\ s_{23}' & s_{33}' & s_{13}' & 0 & s_{36}' & 0 \\ s_{12}' & s_{13}' & s_{11}' & 0 & s_{16}' & 0 \\ 0 & 0 & 0 & s_{55}' & 0 & s_{45}' \\ s_{26}' & s_{36}' & s_{16}' & 0 & s_{66}' & 0 \\ 0 & 0 & 0 & s_{45}' & 0 & s_{44}' \end{vmatrix} \tag{7}$$

where the subscripts of the primed values are those according to Voigt.

*Monoclinic, class 2*

$$d = \begin{vmatrix} 0 & 0 & 0 & d_{25}' & 0 & d_{24}' \\ d_{32}' & d_{33}' & d_{31}' & 0 & d_{36}' & 0 \\ 0 & 0 & 0 & d_{24}' & 0 & d_{14}' \end{vmatrix} \tag{8}$$

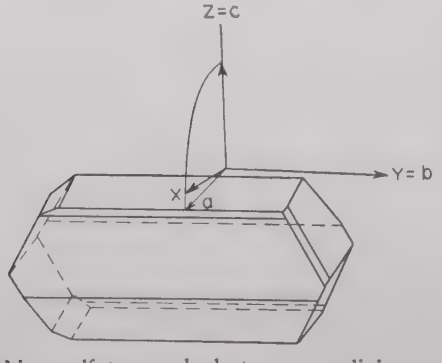


Fig. 4—Lithium sulfate monohydrate, a monoclinic crystal, class 2. The specimen here shown is left-handed. On extension along the $b$ axis, the $+b$ end becomes negatively charged.

*Monoclinic, class m*

$$d = \begin{vmatrix} d_{22}' & d_{23}' & d_{21}' & 0 & d_{26}' & 0 \\ 0 & 0 & 0 & d_{35}' & 0 & d_{34}' \\ d_{12}' & d_{13}' & d_{11}' & 0 & d_{16}' & 0 \end{vmatrix}. \tag{9}$$

Examples of monoclinic crystals are shown in Figs. 4, and 5, and 6.

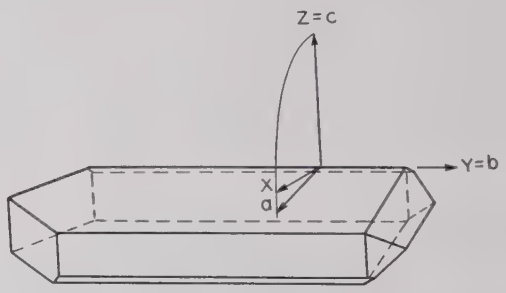


Fig. 5—Ethylene diamene $d$-tartrate (EDT), a monoclinic crystal, class 2.
On extension along the $b$ axis, the $+b$ end becomes positively charged.

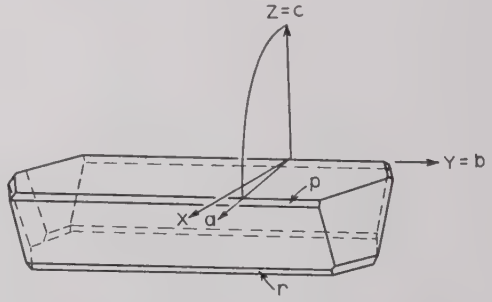


Fig. 6—Dipotassium $d$-tartrate (DKT), a monoclinic crystal, class 2. On extension along the $b$ axis, the $+b$ end becomes positively charged.

### 1.5. The Orthorhombic System

Crystals having three mutually perpendicular twofold axes or two mutually perpendicular planes of reflection symmetry, or both, belong to the orthorhombic

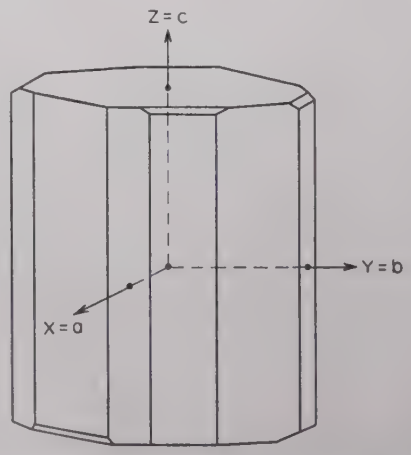


Fig. 7—Rochelle salt, an orthorhombic crystal, class 2 2 2.

system. The unit cell is a right-angled parallelepiped with the *a*, *b*, *c* axes of unequal length, and with unit distances $c_0 < a_0 < b_0$. Either end of any two axes may be taken as positive. The third axis is then given the proper sense to form a right-handed system. The following convention has been universally adopted: "*X* along *a*, *Y* along *b*, *Z* along *c*."

An example of an orthorhombic crystal is Rochelle salt, Fig. 7.

### 1.6. The Tetragonal System

Crystals having a single fourfold axis (or a fourfold inversion-axis) belong to the tetragonal system. The *c* axis is always taken along this fourfold axis, and the *Z* axis lies along *c*. The *a* and *b* axes are equivalent and are usually called $a_1$ and $a_2$. The *X* axis may be parallel to either $a_1$ or $a_2$; that is, to either *a* or *b* in Fig. 8. There are thus two possible sets of *X* and *Y* axes.

The orientation of *a* and hence of *X* is not so easily settled. There are seven classes of tetragonal crystals, five of which can be piezoelectric; these are classes $\bar{4}$, 4, $\bar{4}$ 2 *m*, 4 2 2, and 4 *m m*. Three of these have no twofold axes to guide in a choice of an *a* axis; however, for all of them except class $\bar{4}$ 2 *m* there is no alternative to the choice of an *a* axis in such a way as to make the unit cell of smallest volume. In class $\bar{4}$ 2 *m*, which has a twofold axis, the smallest cell may not have its *a* axis parallel to this axis. There are twelve possible arrangements of matter (space-groups) that have symmetry $\bar{4}$ 2 *m*. Of these twelve, six have the smallest cell when the *a* axis is an axis of twofold symmetry, and six have the smallest cell when *a* is chosen at 45 degrees to twofold axes (while still perpendicular to the *c* axis). The "International Tables for the Determination of Crystal Structure" give preference to the choice: "*a* along a twofold axis," and hence do not use the smallest possible cell. For piezoelectric studies this choice is more convenient than the smallest-cell choice. Since there is such good precedent for letting *a* lie along a twofold axis, there seems little likelihood of a conflict here.

In summary, it may be stated that for all tetragonal crystals having axes of twofold symmetry, one of these axes is taken as the *a* axis. When there is no twofold axis, the *a* axis is parallel to one of the two equal dimensions of the smallest unit cell. Arbitrarily take one end of the *c* axis as positive. Then use section 1.16 as a guide for the sense of the *a* axis as well as, in class $\bar{4}$ 2*m*, for the choice of the *a* axis.

The $+Z$ and $+X$ axes coincide with the $+c$ and $+a_1$ (or $+a_2$) axes respectively. The $+Y$ axis is such as to complete the right-handed rectangular axial system.

### 1.7. Application to Crystals of the ADP Type

Ammonium dihydrogen phosphate (ADP, Fig. 8), potassium dihydrogen phosphate (KDP), and the dihydrogen arsenates of ammonium and potassium, are all in class $\bar{4}$ 2 *m*. Since with these crystals the particular faces that would be needed to determine the positive senses of the *a* axes are usually absent, the following empirical rule is adopted. It is based on the fact that compression along a line 45 degrees from the *a* and *b* axes polarizes the crystal in the *c* direction, causing opposite charges to appear at the ends of the *c* axis. Stretching along the same line reverses the signs of the charges.

The rule is that the direction of a stretch (extension) that causes a positive charge to appear at the end of the *Z* axis which is chosen as the positive end, should lie in the quadrant between the positive directions of the *X* and *Y* axes. There are obviously two choices of positive directions, since the rule still holds if both axes are reversed. The rule is in accord with Section 1.16, (4) and (9).

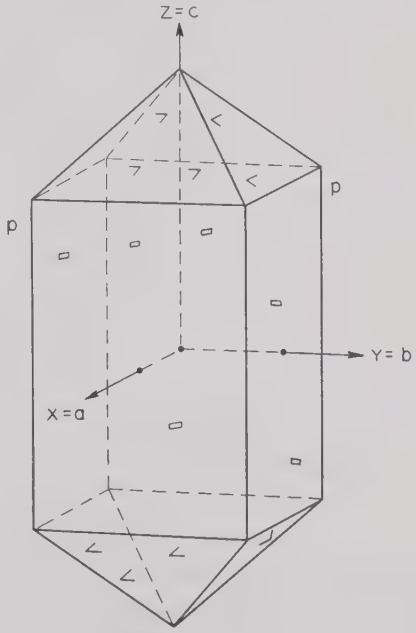


Fig. 8—Ammonium dihydrogen phosphate (ADP), a tetragonal crystal, class $\bar{4}$ 2 *m*. Potassium dihydrogen phosphate (KDP) is similar.
On extension along the diagonal *pp*, the $+z$ end becomes negatively charged.
Typical etch figures are shown on various faces.

### 1.8. The Hexagonal and Trigonal Systems

These systems are distinguished by an axis of sixfold (or threefold) symmetry. This axis is always called the *c* axis. According to the Bravais-Miller axial system, which is most commonly used, there are three equivalent secondary axes, $a_1$, $a_2$, and $a_3$, lying 120 degrees apart in a plane normal to *c*. These axes are chosen as being either parallel to a twofold axis or perpendicular to a plane of symmetry, or if there are neither twofold axes perpendicular to *c* nor planes of symmetry parallel to *c*, the *a*'s are chosen so as to give the smallest unit cell.

According to the present convention, the *Z* axis is parallel to *c*. The *X* axis coincides in direction and sense

with any one of the $a$ axes. The $Y$ axis is perpendicular to $Z$ and $X$, so oriented as to form a right-handed system. This rule applies to both right- and left-handed crystals.

The axes of tourmaline are shown in Fig. 9.

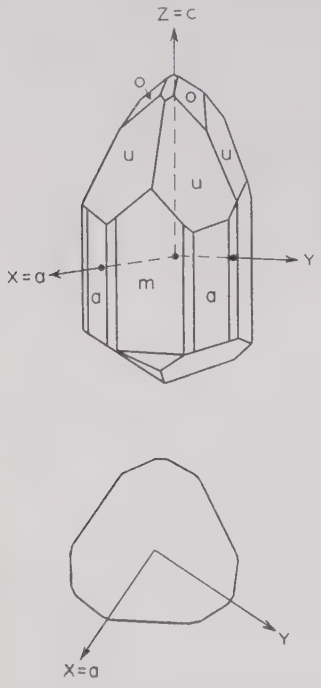


Fig. 9—Tourmaline, a trigonal crystal, class 3 $m$.
The $Y$ axis lies in the plane of symmetry. On extension along $Y$ the $+Y$ end becomes positively charged. On extension along $Z$ the $+Z$ end becomes positively charged.

### 1.9. Application to Quartz

The axes according to the present convention are shown in Fig. 10. With both right and left quartz the $X$, $Y$, $Z$ axes form a right-handed system. The effect of these changes[4] on the signs of elastic and piezoelectric constants and on the formulas for rotated axes is discussed in Section 1.12.

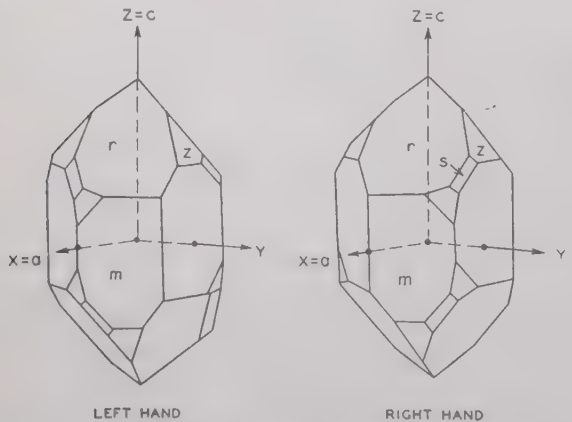


Fig. 10—Left and right quartz crystals, trigonal, class 3 2.

[4] For right quartz both $X$ and $Y$ axes are reversed with respect to the 1945 convention. For left quartz the $Y$ axis is reversed, while the $X$ axis is unchanged.

### 1.10. The Isometric (Cubic) System

The three equivalent axes are $a$, $b$ $(=a)$, and $c$ $(=a)$, often called $a_1$, $a_2$, and $a_3$. They are chosen parallel to axes of fourfold symmetry, or, if there is no true fourfold symmetry, then parallel to twofold axes. The $X$, $Y$, and $Z$ axes form a right-handed system parallel to the $a$, $b$, and $c$ axes.

An example is sodium bromate, Fig. 11.

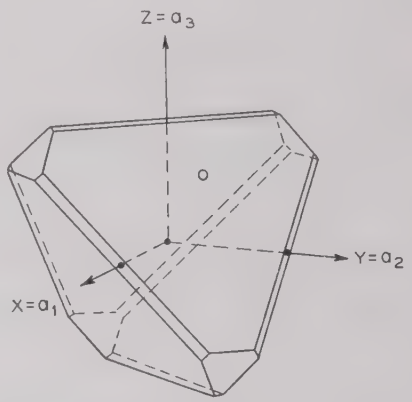


Fig. 11—Right crystal of sodium bromate, an isometric crystal, class 2 3.

### 1.11. Axes of Enantiomorphous Forms

In the following piezoelectric classes, both right and left forms are possible: triclinic 1, monoclinic 2, orthorhombic 2 2 2, tetragonal 4 and 4 2 2, trigonal 3 and 3 2, hexagonal 6 and 6 2 2, and isometric 2 3.

If a right crystal is placed in any orientation in front of a mirror, the image as seen in the mirror represents the corresponding left crystal. If the right crystal has right-handed rectangular axes, the axes of the left crystal will then appear left-handed. Nevertheless, it is standard crystallographic practice to use *right-handed axial systems for all crystals, whether right or left.* This convention is adopted in the present Standard for piezoelectricity. Under this convention the left form should be regarded as the crystallographic *inversion* of the right form, rather than as its mirror image.[5]

The signs of all elastic constants are the same for left and right crystals. Piezoelectric constants, however, have *opposite* signs for left and right crystals.

### 1.12. Special Conventions for Quartz

The rules given in the foregoing paragraph will now be applied to ordinary quartz, class 3 2 (alpha-quartz, the form occurring at temperatures below the $\alpha$-$\beta$ inversion point at 573° C).

The present convention for axes of right and left quartz has been stated in Section 1.9 (see Fig. 10). This choice of axes involves certain conventions respecting

[5] The inversion of any solid figure is produced by drawing from each point a line through an arbitrary point $P$ and continuing this line for an equal distance beyond $P$. An inversion is equivalent to a 180 degree rotation about any axis through $P$ followed by reflection in a mirror perpendicular to this axis of rotation at the point $P$.

the elastic constants $c_{14}$ and $s_{14}$, as well as the piezoelectric constants $d_{11} = -d_{12} = -d_{26}/2$, $e_{11} = -e_{12} = -e_{26}$, $d_{14} = -d_{25}$, and $e_{14} = -e_{25}$.

Elastic constants: under this convention, *for both right and left quartz, $c_{14}$ is negative, $s_{14}$ is positive.**

As may be verified from the well-known fundamental equations ((11) and (12) in part 3), the *piezoelectric constants* of quartz must have the following algebraic signs in conformity with the present axial system:

Right quartz: $d_{11}$ negative, $e_{11}$ negative,
$d_{14}$ negative, $e_{14}$ positive.

Left quartz: $d_{11}$ positive, $e_{11}$ positive,
$d_{14}$ positive, $e_{14}$ negative.

When the piezoelectric constants $g$ and $h$, occurring in (13) to (16) of part 3, are specialized for quartz, they become $g_{11}$, $g_{14}$, $h_{11}$, $h_{14}$, corresponding to Voigt's $d_{11}$, $d_{14}$, $e_{11}$, $e_{14}$, respectively. In all cases their signs are the same as those of $d_{11}$, $d_{14}$, $e_{11}$, and $e_{14}$, respectively.

### 1.13. Summary of Rules for Determining the Axes and Hand of Quartz Crystals According to the Present Recommendations

(A) The $+X$ axis should coincide with a $+a$ crystallographic axis, and the $Z$ axis should coincide with the $c$ crystallographic axis, as in Fig. 10.

(B) On extension, the positive ends of the $a$ axes, and

TABLE I

| Crystal System | Hermann-Mauguin Symbol | Axes: Crystallographic $c$ | $a$ | $b$ | Axes: Rectangular $X$ | $Y$ | $Z$ | +/− Axes | Schoenflies Symbol | Example |
|---|---|---|---|---|---|---|---|---|---|---|
| Triclinic $c_0<a_0<b_0$ $\alpha$ & $\beta>90°$ | 1 | | | | | ⊥ (010) | | | $C_1$ | Aminoethyl ethanolamine hydrogen *d*-tartrate (AET) |
| | $\bar{1}$ | | | | | ⊥ (010) | $c$ | | $S_2$ | Copper sulfate pentahydrate |
| Monoclinic $c_0<a_0$ $\beta>90°$; $\alpha=\gamma=90°$ | $m$ | | | $/m$ | ⊥ (100) | $b$ | $c$ | $X$ or $Z$ | $C_{1h}=C_s$ | Clinohedrite |
| | 2 | | | 2 | ⊥ (100) | $b$ | $c$ | | $C_2$ | Ethylene diamine *d*-tartrate (EDT) |
| | $2/m$ | | | 2 | ⊥ (100) | $b$ | $c$ | | $C_{2h}$ | Gypsum |
| Orthorhombic $c_0<a_0<b_0$ (for 2 2 2 & $2/m$ $2/m$ $2/m$ $\alpha=\beta=\gamma=90°$) | 2 2 2 | 2 | 2 | 2 | $a$ | $b$ | $c$ | | $V=D_2$ | Rochelle salt (except between Curie points) |
| | 2 $m$ $m$ | 2 | $/m$ | $/m$ | $a$ | $b$ | $c$ | $Z$ | $C_{2v}$ | Hemimorphite |
| | $2/m$ $2/m$ $2/m$ | 2 | 2 | 2 | $a$ | $b$ | $c$ | | $V_h=D_{2h}$ | Barite |
| | | $c$ | $a_1$ | $a_2$ | | | | | | |
| Tetragonal $a_0=b_0$ $\alpha=\beta=\gamma=90°$ | 4 $m$ $m$ | 4 | $/m$ | $/m$ | $(a_1)$ | $(a_2)$ | $c$ | $Z$ | $C_{4v}$ | Silver fluoride monohydrate |
| | $\bar{4}$ 2 $m$ | $\bar{4}$ | 2 | 2 | $(a_1)$ | $(a_2)$ | $c$ | $Z$ | $V_d=D_{2d}$ | Ammonium dihydrogen phosphate (ADP) |
| | 4 2 2 | 4 | 2 | 2 | $(a_1)$ | $(a_2)$ | $c$ | * | $D_4$ | Nickel sulfate hexahydrate |
| | $4/m$ $2/m$ $2/m$ | 4 | 2 | 2 | $(a_1)$ | $(a_2)$ | $c$ | * | $D_{4h}$ | Zircon |
| | 4 | 4 | † | | $(a_1)$ | $(a_2)$ | $c$ | $Z$ | $C_4$ | Barium antimonyl tartrate |
| | $\bar{4}$ | $\bar{4}$ | † | | $(a_1)$ | $(a_2)$ | $c$ | $Z$ | $S_4$ | $Ca_2Al_2SiO_7$ |
| | $4/m$ | 4 | † | | $(a_1)$ | $(a_2)$ | $c$ | * | $C_{4h}$ | Scheelite |
| Isometric $a_0=b_0=c_0$ $\alpha=\beta=\gamma=90°$ | 2 3 | 2 | 2 | 2 | $(a_1)$ | $(a_2)$ | $a_3$ | $Z$ | $T$ | Sodium chlorate |
| | $\bar{4}$ 3 $m$ | $\bar{4}$ | $\bar{4}$ | $\bar{4}$ | $(a_1)$ | $(a_2)$ | $a_3$ | $Z$ | $T_d$ | Zinc blende (Sphalerite) |
| | 4 3 2 | 4 | 4 | 4 | $(a_1)$ | $(a_2)$ | $a_3$ | * | $O$ | None known |
| | $2/m$ $\bar{3}$ | 2 | 2 | 2 | $(a_1)$ | $(a_2)$ | $a_3$ | * | $T_h$ | Pyrite |
| | $4/m$ $\bar{3}$ $2/m$ | 4 | 4 | 4 | $(a_1)$ | $(a_2)$ | $a_3$ | * | $O_h$ | Sodium chloride |
| | | $c$ | $a_1$ | $a_2$ | $a_3$ | | | | | |
| Trigonal $(a_0)_1=(a_0)_2=(a_0)_3$ | 3 | 3 | † | | | $a_1$ | | $c$ | any two | $C_3$ | Sodium periodate trihydrate |
| | $\bar{3}$ | $\bar{3}$ | † | | | $a_1$ | | $c$ | | $C_{3i}=S_6$ | Dolomite |
| | 3 $m$ | 3 | $/m$ | $/m$ | $/m$ | $a_1$ | | $c$ | $Y$, $Z$ | $C_{3v}$ | Tourmaline |
| | 3 2 | 3 | 2 | 2 | 2 | $a_1$ | | $c$ | $X$ | $D_3$ | $\alpha$-quartz |
| | $\bar{3}$ $2/m$ | $\bar{3}$ | 2 | 2 | 2 | $a_1$ | | $c$ | $X$ | $D_{3d}$ | Calcite |
| Hexagonal $(a_0)_1=(a_0)_2=(a_0)_3$ | $\bar{6}$ | $\bar{6}$ | † | | | $a_1$ | | $c$ | $X$, $Y$ | $C_{3h}$ | None known |
| | $\bar{6}$ $m$ 2 | $\bar{6}$ | 2 | 2 | 2 | $a_1$ | | $c$ | $X$ | $D_{3h}$ | Benitoite (?) |
| | 6 | 6 | † | | | $a_1$ | | $c$ | $Z$ | $C_6$ | Nephelite |
| | 6 $m$ $m$ | 6 | $/m$ | $/m$ | $/m$ | $a_1$ | | $c$ | $Z$ | $C_{6v}$ | Wurtzite—2H |
| | 6 2 2 | 6 | 2 | 2 | 2 | $a_1$ | | $c$ | | $D_6$ | $\beta$-quartz |
| | $6/m$ | 6 | | | | $a_1$ | | $c$ | | $C_{6h}$ | Apatite |
| | $6/m$ $2/m$ $2/m$ | 6 | 2 | 2 | 2 | $a_1$ | | $c$ | | $D_{6h}$ | Beryl |

* Equations for the elastic constants of quartz for rotated axes, as, for example, equations (50)–(54) in footnote reference 2, remain unchanged, owing to the reversal in sign of certain direction cosines on passing from the old to the present axial system.

therefore of the $X$ axes, become negatively charged with right quartz, positively charged with left quartz.

(C) For right-handed quartz, the conoscope interference rings expand when the analyzer is turned clockwise by the observer.

### 1.14. Choice of Axes for Piezoelectric Crystals

Axes are assigned to crystals according to Table I. Crystal classes are listed, using the full Hermann-Mauguin symbols to designate the class. The method of selection of both the crystallographic axes and the rectangular axes of physics and engineering is to be read from the table. $a$, $b$, $c$ are the crystallographic axes (Sections 1.3 to 1.10, and 1.13); $a_0$, $b_0$, $c_0$ refer to the dimensions of the unit cell along these axes; $X$, $Y$, $Z$ are the rectangular axes, which should always form a right-handed system, whether for a left or a right crystal (Sections 1.9 and 1.11 to 1.13). $\alpha$, $\beta$, $\gamma$ are the angles between the pairs of crystallographic axes (Section 1.3). Both the Schoenflies and the Hermann-Mauguin symbols are given, although the use of the latter is preferred.

*Explanation of Table I*

In the column "Hermann-Mauguin Symbols" those classes which are piezoelectric are placed at the left.

Under "Axes," the numerals 2, 3, 4, 6 mean an axis of two-, three-, four- or six-fold symmetry; $\bar{4}$ (read 4 bar) a fourfold, $\bar{6}$ a sixfold axis of inversion; $m$ an axis in a plane of symmetry; $/m$ an axis perpendicular to a plane of symmetry.

$a$, $b$, $c$ are the crystallographic axes; $X$, $Y$, $Z$ the rectangular axes. In some systems all, or two, of these axes are physically indistinguishable and said to be equivalent; the same symbol is then often repeated for the several equivalent axes, using a different subscript for each, as $a_1$, $a_2$, $a_3$.

$a_0$, $b_0$, $c_0$ are the edge lengths of the unit cell, parallel to the $a$, $b$, $c$ axes, respectively.

$\alpha$, $\beta$, $\gamma$ are the angles between $c$ and $b$, $a$ and $c$, $b$ and $a$, respectively.

The procedure for determining the $a$, $b$, $c$ axes of any crystal involves satisfying a series of conventions. The first convention is indicated under the name of each system, and gives general rules for identification of axes in terms of the relative magnitudes of the several unit distances and of the angles between the crystallographic axes. With triclinic crystals, and with orthorhombic classes 2 2 2 and $2/m$ $2/m$ $2/m$, this one rule (Section 1.3) unambiguously prescribes all crystallographic axes and their senses. With monoclinic crystals a further rule is imposed, namely that the $b$ axis is defined in terms of the symmetry according to the third column under "Axes." With the remaining systems the $c$ axis is the first to be identified and is always the axis of high symmetry. Where the symbol † appears there is no special rule beyond that for the choice of the $c$ axis, except that the remaining axes shall be selected in such a way as to give the smallest cell consistent with the specification of $c$.

Parentheses around $a_1$ and $a_2$ in columns 6 and 7 (tetragonal and isometric classes) indicate that the designation is arbitrary as to which of the two crystallographic axes perpendicular to $c(Z)$ shall be $X$ and which shall be $Y$. Except for class $\bar{4}$ $2m$, either choice of sense may be made for the $Z$ axis, after naming the $X$ axis, and the choice will not affect the signs of the constants. The only restriction is that the axial system shall be right-handed. In three tetragonal classes (4 2 2, $4/m$ $2/m$ $2/m$ and $4/m$) and three isometric classes (4 3 2, $2/m$ $\bar{3}$ and $4/m$ $\bar{3}$ $2/m$) this choice is trivial in the sense that the signs, values and matrix positions of elastic, dielectric or piezoelectric constants are in no way affected thereby. These six classes are designated by an asterisk (*) in column 9.

The column headed "+/− Axes" indicates classes for which the rules given do not uniquely determine the axial system, particularly with respect to the senses of certain axes. A single axial symbol appearing in this column indicates that the sense of the axis named remains to be chosen by the first worker in the field, and that the signs of certain of the piezoelectric constants will depend upon the choice. See Section 1.16 for guidance in making this choice. Two letters in this column indicate that the two axes named may be similarly chosen, in general the first choice affecting the signs of certain piezoelectric constants and the second choice affecting those of some others. In the two situations named, there may also be certain piezoelectric constants whose signs are not affected by the choices. Finally, in class 3, as indicated, the senses of any two axes remain to be chosen and the choice affects the signs of the piezoelectric constants.

### 1.15. The Hermann-Mauguin Symbols[6]

In this system of notation an axis of rotation is indicated by one of the numbers 1, 2, 3, 4, 6. The number indicates through its reciprocal the part of a full rotation about the axis which is required to bring the crystal into an equivalent position in regard to its internal structural properties. The number 1 indicates no symmetry at all, since any structure must come back into coincidence after a complete rotation, while 2 indicates a twofold axis of rotation. $\bar{1}$, $\bar{2}$, $\bar{3}$, $\bar{4}$, $\bar{6}$ indicate axes of rotary inversion. $\bar{1}$ implies a simple center of inversion. $\bar{2}$ is equivalent to a reflection plane and since reflection planes are so important a feature of the structure the symbol for such a plane, $m$, is written instead of $\bar{2}$. If an axis has a reflection plane perpendicular to it, this fact is written as part of the symbol for that axis by following the number which describes the symmetry of the axis with the notation $/m$.

[6] Adapted from W. H. Bragg and W. L. Bragg, "The Crystalline State," vol. I, pp. 85–86, G. Bell and Co., London, 1933.

The designation for any class of symmetry is made up of one, two, or three symbols, each indicating an element of the symmetry. *The first symbol* in general refers to the principal axis of the crystal if there is one, indicating the type of symmetry of that axis and the existence of a reflection plane perpendicular to that axis, if any. *The second symbol* refers to secondary axes of the crystal, giving similarly the character of the symmetry involved and including reference to a reflection plane perpendicular to it if such exists, or refers to a reflection plane alone if no secondary axes exist. In the isometric system the secondary axes are the threefold axes inclined to the principal axis. *The third symbol* names tertiary axes if they exist, such as those parallel to $(11\bar{2}0)$ in the hexagonal system or (110) in the tetragonal system, or corresponding planes.

### 1.16. Positive Sense Guide

In lieu of other guiding factors, the following is suggested as a rule for guidance in setting up the axial system for crystals which are piezoelectric. Axial senses (as well as the selection of the $Z$ axis or the choice between $X$ and $Y$ axes when this needs to be made) shall be those which provide a positive sign for the first one of the following constants which does not vanish: $d_{33}$, $d_{11}$, $d_{22}$, $d_{36}$, $d_{31}$. This selection of the group of sense-determining constants is somewhat arbitrary, giving emphasis to the crystallographic importance of the $Z$ axis and to providing positive signs for the piezoelectric constants of extensional strain along axial fields. If the first application of the rule is not sufficient to determine uniquely the senses of all axes, then the rule is to be applied again to the second one of the constants which does not vanish; and again to the third if necessary. For crystals which are enantiomorphic, the rule should be applied as stated to the right crystal; for left crystals, the rule should read "negative" instead of "positive" in each reference to a piezoelectric constant. The senses of axes in the left crystal should be such as to reverse the signs of all piezoelectric constants with respect to those of the right crystal.

The effects of the application of the rule in the several classes may be summarized as follows:

(1) A positive $d_{33}$ determines the sense of the $Z$ axis in classes $m$, 2 $m$ $m$, 4 $m$ $m$, 4, 3, 3 $m$, 6, 6 $m$ $m$.
(2) A positive $d_{11}$ determines the sense of the $X$ axis in classes 3, 3 2, $\bar{6}$, $\bar{6}$ $m$ 2.
(3) A positive $d_{22}$ determines the sense of the $Y$ axis in classes 3 $m$, $\bar{6}$.
(4) A positive $d_{36}$ determines the distinction between $X$ and $Y$ axes in class $\bar{4}$ 2 $m$.
(5) A positive $d_{14}=d_{36}$ determines the distinction between $X$ and $Y$ axes in classes 2 3, $\bar{4}$ 3 $m$ after any one of the three crystallographic axes has been chosen arbitrarily as $Z$ axis.
(6) A positive $d_{31}$ determines the sense of the $Z$ axis in class $\bar{4}$.
(7) The senses of all axes are trivial and reversals such as to maintain a right-axial system do not affect the signs of piezoelectric constants in classes 2 2 2, 4 2 2, 6 2 2.
(8) The senses of $X$ and $Z$ axes are trivial in class 2, and reversals such as to maintain a right-axial system do not affect the signs of piezoelectric constants.
(9) The senses of $X$ and $Y$ axes are trivial in classes $\bar{4}$ 2 $m$, 2 3, $\bar{4}$ 3 $m$, 2 $m$ $m$, 4 $m$ $m$, 4, 6, 6 $m$ $m$.
(10) The sense of the $Y$ axis is trivial in classes 3 2, $\bar{6}$ $m$ 2.

## 2. Standard for Specifying Crystal Plate Orientation

*2.1.* All crystal plate specifications for orientation are to be determined by a "Rotational Symbol." This symbol is a set of letters and angles that indicate a way in which the orientation of the plate, assumed to be rectangular, can be derived from one of six initial orientations by successive rotations about plate edges.

The initial orientation is that in which the thickness, length and width fall along the $X$, $Y$, and $Z$ axes, but not necessarily respectively. The $X$, $Y$, and $Z$ axes for the various crystal systems are defined in part 1.

A. The first two letters of the symbol indicate the initial orientation used.
   (a) The *first* letter is $x$, $y$, or $z$ and indicates the direction of the plate *thickness* before any rotations have been made.
   (b) The *second* letter is $x$, $y$ or $z$ and indicates the direction of the plate *length* before any rotations.
   (c) These two letters completely specify unrotated plates. Figs. 12 to 17 show the six possible cuts that require no rotation.

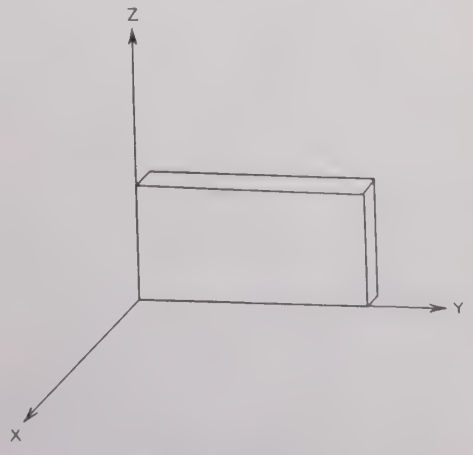


Fig. 12—An ($xy$) cut.

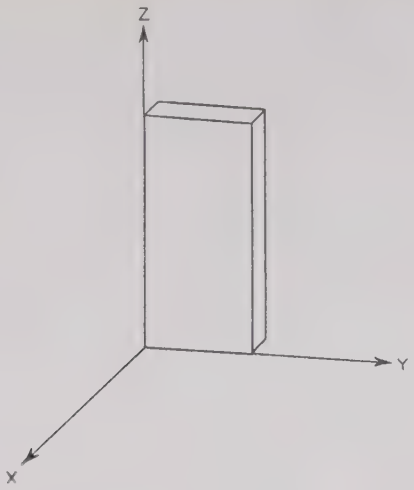


Fig. 13—A (*xz*) cut.

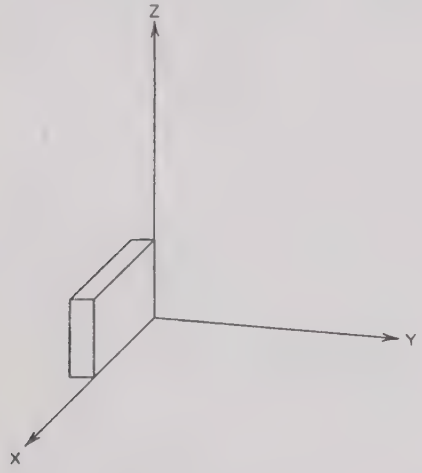


Fig. 14—A (*yx*) cut.

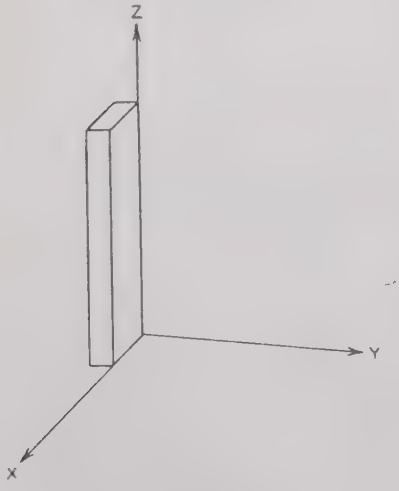


Fig. 15—A (*yz*) cut.

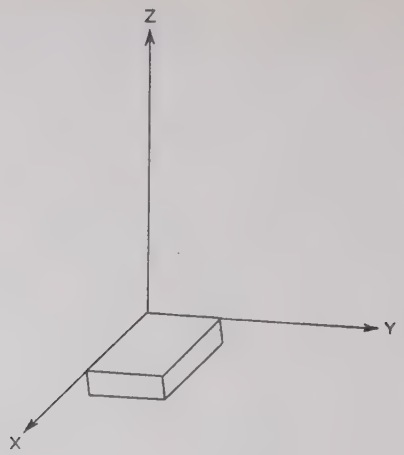


Fig. 16—A (*zx*) cut.

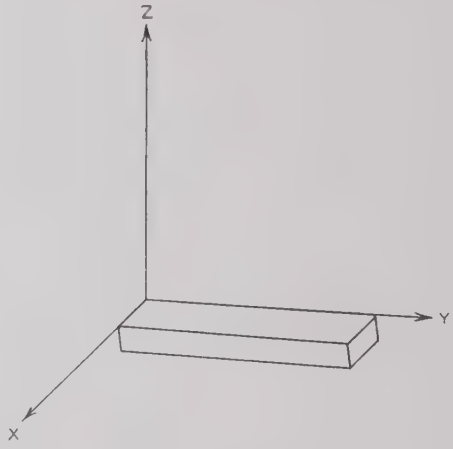


Fig. 17—A (*zy*) cut.

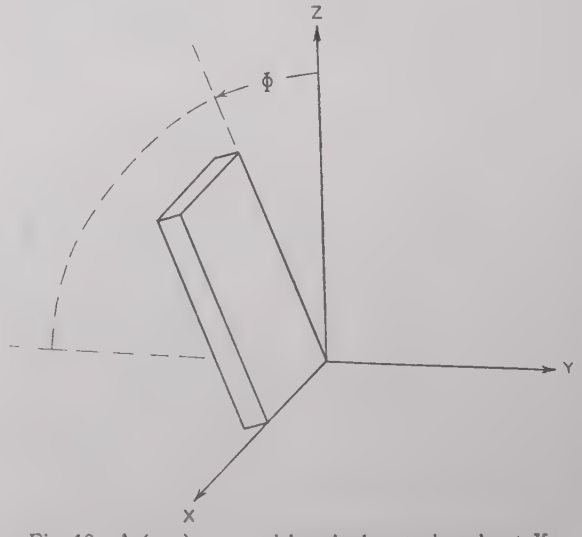


Fig. 18—A (*yzw*) cut, positive single rotation about *X*.

B. The remaining letters of the symbol indicate the plate edges used as axes of rotation.

(a) The *third* letter of the symbol is *t*, *l*, or *w* according to whether the thickness direction, length direction or width direction is the axis of first rotation. If one rotation suffices there are only three letters in the symbol. Several commonly used single rotation cuts of quartz are shown in Figs. 18 to 21.

(b) The *fourth* letter is *t*, *l*, or *w* according to the edge used for the second rotation. If two rotations suffice there are only four letters in the

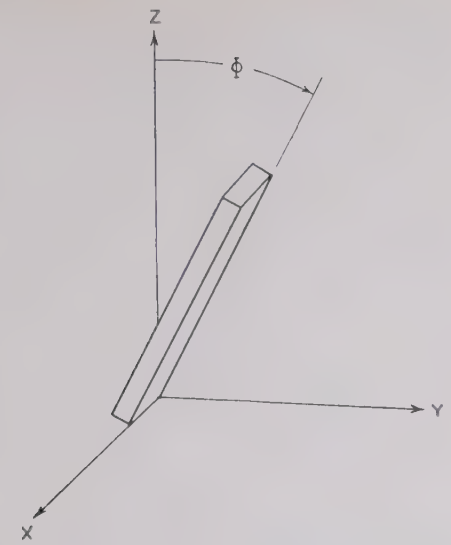


Fig. 19—A (*yzw*) cut, negative single rotation about *X*.

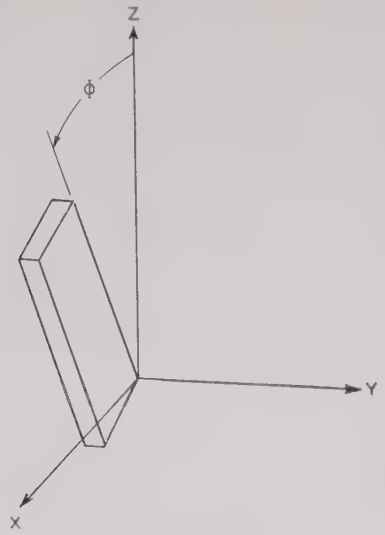


Fig. 21—A (*yzt*) cut, rotation about *Y*.

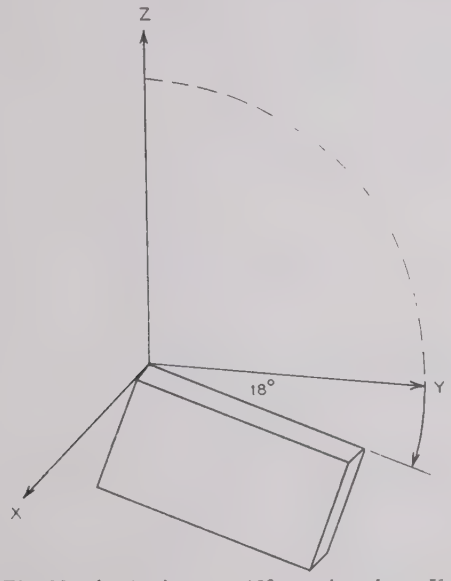


Fig. 20—An (*xyt*) cut, −18° rotation about *X*.

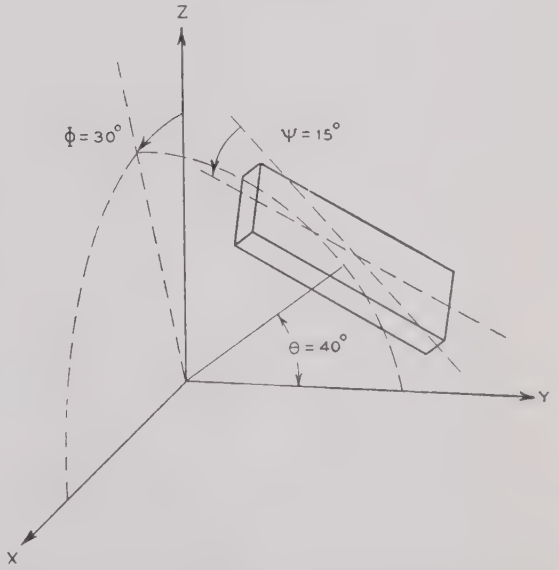


Fig. 23—A triple-rotation cut (*yztwt*), produced from Fig. 22(c) by 15° rotation about *t*.

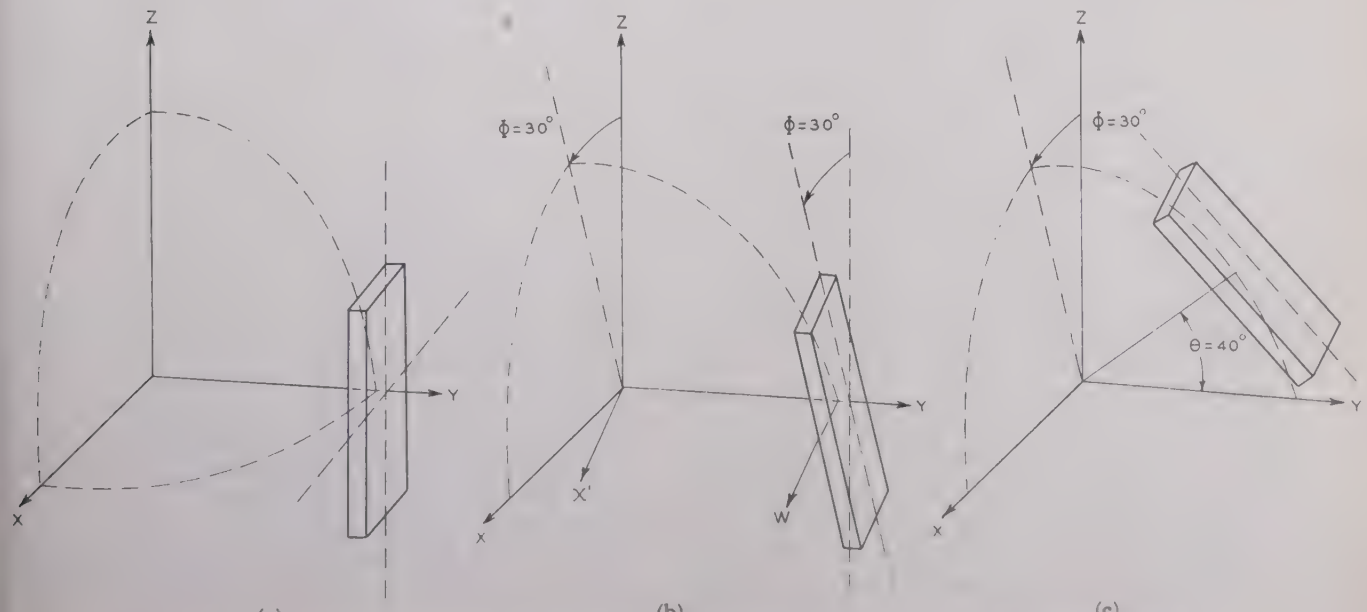


Fig. 22—A double-rotation cut (*yztw*) arrived at by 30° rotation about *t* followed by 40° rotation about *w*

symbol. A double-rotation cut is shown in Fig. 22.

(c) The *fifth* letter is $t$, $l$, or $w$ according to the edge used for the third rotation. There need be no more than five letters in the symbol. A triple-rotation cut is shown in Fig. 23.

C. The symbol is to be followed by a list of rotation angles $\Phi$, $\Theta$, $\Psi$; angles negative in sense will be indicated by a negative sign.

(a) A positive angle means rotation counter-clockwise as seen looking toward the origin from the positive end of the axis of rotation.

(b) The positive ends of the axes $t$, $l$, and $w$ are the ends that initially pointed in the positive directions of the three coordinate axes $X$, $Y$ and $Z$.

D. Right-handed crystals and left-handed crystals (see Fig. 10) use exactly the same symbol and angle list to give *elastically* equivalent plates. As is explained in Section 1.12, the signs of all piezoelectric constants for right crystals are opposite to those for left crystals. Nevertheless, the numerical values of the piezoelectric constants are the same for left as for right crystals (see also Section (b) below).

(a) A left-handed crystal is considered as the crystallographic inversion of a right-handed crystal rather than as its mirror image (see Section 1.11).

(b) The case of crystals that exist in both right-handed and left-handed forms, as is the case for quartz, will now be discussed. Consider a plate $R$ made from a right-handed crystal according to some one orientation specification. What orientation specification will produce, from a left-handed crystal, a plate $L$ with properties identical to those of plate $R$? The answer is that it is impossible to orient the $L$ plate so that *all* its properties are identical with those of the $R$ plate. It is, however, possible so to orient $L$ as to have its elastic properties identical with those of $R$, and the piezoelectric properties differing only in sign. This "equivalence" is satisfactory in most piezoelectric work. A left crystal can be so positioned with respect to a right crystal that it can be considered as the right crystal inverted through a center of inversion. (Place them in a mirror-image relation first, then rotate one of them 180° in the plane of the mirror.) In this relative position, we can describe the two crystals on identical systems of axes. Each face $(hkl)$ of one crystal is now matched by a parallel face, $(\bar{h}\bar{k}\bar{l})$ of the other crystal; the plate $R$ of one crystal is now parallel to the plate $L$ of the other crystal, $R$ and $L$ having the "equivalence" mentioned above. Hence *the rotation-system symbol is the same for both plates.* If when sawing to produce a given orientation the crystals are supported on two or more faces (reference faces) which rest on surfaces of a sawing fixture, this fixture will serve for both right and left forms if the crystal has a second face parallel to each reference face. This is ordinarily the case for all but crystals of low symmetry, such as triclinic asymmetric crystals.

E. As examples of the association of familiar angles, a quartz $AT$ plate, with its length along the $X$ axis, is designated as $(yxl)$ 35 1/4°. A $BT$ cut is $(yxl)$ $-49°$. It is to be noted that most manufacturers are accustomed to the descriptions 35 1/4° rotated $Y$ cut and $-49°$ rotated $Y$ cut respectively for these two crystals. The designation of the familiar 45° $X$ cut Rochelle salt plate is $xyt$ 45°; of the 45° $Z$ cut plate of $ADP$, $zxt$ 45°; and of the $Y$ cut of $EDT$, $yx$.

It is convenient to add the angles and the dimensions to the rotation symbol to complete the crystal plate specification. For example, as in Fig. 23, $(yztwl)$ 30°/15°/40° means $(yztwl)$ with $\Phi = 30°$ about $t$, $\Theta = 15°$ about $w$, and $\Psi = 40°$ about $l$. A statement of the final required dimensions will now complete the specification, so that a full specification might read:

$$(yztwl)\ 30°/15°/40°$$
$$t = 0.80 \pm 0.01 \text{ mm}$$
$$l = 40.0 \pm 0.1 \text{ mm}$$
$$w = 9.03 \pm 0.03 \text{ mm}.$$

F. It might be thought that an independent set of rotation systems would result if the rotations were about $X$, $Y$, and $Z$ in some order instead of about $t$, $l$ and $w$. For example, we might extend our nomenclature to cover such a symbolization as $(yxxyz)$. Here the $yx$ tells us that the thickness was originally along $Y$ and the length originally along $X$. The $xyz$ tells us that the first rotation is about the $X$ axis, the second about the $Y$ axis, and the third about the $Z$ axis. For single rotations there is no difference between this and the previous system as, for example, a $(yxx)$ is identical with a $(yxl)$ since $x$ and $l$ coincide in this case. For multiple rotations it can be shown that a simple relation connects the two sets, $(yxxyz)\alpha/\beta/\gamma$ being in fact equivalent to $(yxwtl)\gamma/\beta/\alpha$. (Note that although $x$, $y$, $z$ coincide initially with $l$, $t$, $w$, respectively, the $ltw$ is reversed with respect to $wtl$ and the order of the angles is also reversed in writing the equivalent symbol.) For example, a quartz $GT$ cut is either a $(yxlt)$ 51°/45° or alternatively a $(yxyx)$ 45°/51°. The $(yxwtl)$ form is to be preferred for the reason that most designers think in these terms, not in the $(yxxyz)$ terms. This is because the $(yxwtl)$ type preserves the direction of one crystal edge for each rotation and hence preserves certain plate properties but allows other properties to vary, thus permitting their improvement. The $(yxxyz)$ type preserves no edge direction of a plate except in the case of singly rotated cuts.

## 3. The Piezoelectric Relations, Symbols, and Units

### 3.1. General

Piezoelectric investigations usually involve the elastic and dielectric constants of the material as well as the piezoelectric. As in other fields, confusion has arisen through the use of different symbols for the same quantity and of the same symbol for different quantities. Additional difficulties have come from Voigt's selection of a compressive stress as positive. This is not in accord with accepted usage by elasticians, nor is it followed by all writers on piezoelectricity.

A suitable notation for the quantities of interest in piezoelectricity should provide a single symbol for each quantity with the various components designated by subscripts to permit the use of either the matrix or tensor methods of writing the equations. This requirement precludes the adoption of either of the two most widely used notations for stress and strain. Piezoelectric notation is further complicated by the fact that, in general, the electrical, mechanical and sometimes the thermal conditions of measurement must be specified before a unique meaning can be given to the constants of the material. It is therefore highly desirable to provide a notation where the boundary conditions can be specified in the symbol.

In order to promote uniformity and accuracy of presentation, a set of standard symbols is here presented. Wherever possible these symbols conform to accepted usage in the field concerned. A table relating them to those used by various authors is also given. The piezoelectric relations that serve to define the constants of the material, together with the various relations among these constants, are given in both matrix and tensor form. These relations are written in rationalized mks units, and a set of factors is given for converting from cgs electrostatic units to rationalized mks units. For comparison with Voigt's notation, the relations are also given, in matrix form, with electrostatic units and Voigt's symbols, but calling the stress positive when tensile.

### 3.2. Specification of the Variables

*3.2.1.* The electrical state of a medium is known when two vector quantities such as electric field and electric displacement are specified. The elastic state is known when two second-order tensor quantities, stress and strain, are specified. Piezoelectricity is concerned with the interaction between the electrical and elastic behavior of a crystal and therefore with relations involving the two electrical and the two elastic variables.

All quantities are referred to rectangular axes designated by $X$, $Y$, and $Z$, or by $X_1$, $X_2$, and $X_3$. These axes are related to the crystallographic axes as explained in part 1 of this Standard.

*3.2.2. The Electrical Variables*

The electrical variables are chosen as the electric field ($E$) and the electric displacement ($D$). The electric displacement is chosen as the second electrical variable in preference to other possible variables (*e.g.*, polarization) as being more useful from an engineering and experimental point of view.

The components of the electric field and electric displacement are designated by $E_i$ and $D_i$, respectively. The subscript $i$ takes the values 1, 2, 3 and denotes the axis along which the component is directed.

*3.2.3. The Elastic Variables*

The elastic variables are stress ($T$) and strain ($S$). The tensor components of stress $T$ are designated by two subscripts ($i=1, 2, 3$ and $j=1, 2, 3$). Since $T_{ij}=T_{ji}$, only 6 of the 9 components are independent, and the stress components can be written with a single subscript $T_p(p=1 \cdots 6)$. $T_p$ can be related to $T_{ij}$ in different ways. The usual convention is represented below.

The relations of the $T_{ij}$ to $T_p$, and to the components of stress as written in certain texts, are as follows (the abbreviated form is the basis of the matrix notation used below).

| Tensor Form | Abbrev. Form | Voigt | Other Texts | |
|---|---|---|---|---|
| $T_{11}$ | $T_1$ | $X_x$ | $\sigma_{xx}$ | Normal stresses |
| $T_{22}$ | $T_2$ | $Y_y$ | $\sigma_{yy}$ | |
| $T_{33}$ | $T_3$ | $Z_z$ | $\sigma_{zz}$ | |
| $T_{23}$ | $T_4$ | $Y_z$ | $\tau_{yz}$ | Shearing stresses. |
| $T_{13}$ | $T_5$ | $Z_x$ | $\tau_{zx}$ | |
| $T_{12}$ | $T_6$ | $X_y$ | $\tau_{xy}$ | |

The tensor strain components are designated by $S_{ij}$. As with the stress components, $S_{ij}=S_{ji}$, so that only six of the strain components are independent and the strain components can also be written with a single subscript $S_p(p=1 \cdots 6)$.

The relations between the strain components in different notations are as follows:

| Tensor Form | Abbrev. Form | Voigt | Other Texts | |
|---|---|---|---|---|
| $S_{11}$ | $S_1$ | $x_x$ | $\epsilon_{xx}$ | Normal strains |
| $S_{22}$ | $S_2$ | $y_y$ | $\epsilon_{yy}$ | |
| $S_{33}$ | $S_3$ | $z_z$ | $\epsilon_{zz}$ | |
| $2S_{23}$ | $S_4$ | $y_z$ | $\gamma_{yz}$ | Shearing strains. |
| $2S_{13}$ | $S_5$ | $z_x$ | $\gamma_{zx}$ | |
| $2S_{12}$ | $S_6$ | $x_y$ | $\gamma_{xy}$ | |

Components of elastic displacement are designated by $u_j(j=1, 2, 3)$ and are related to the strain components as follows:

$$S_1 = S_{11} = \frac{du_1}{dx_1}$$

$$S_2 = S_{22} = \frac{du_2}{dx_2}$$

$$S_3 = S_{33} = \frac{du_3}{dx_3}$$

$$S_4 = 2S_{23} = \frac{du_3}{dx_2} + \frac{du_2}{dx_3}$$

$$S_5 = 2S_{13} = \frac{du_1}{dx_3} + \frac{du_3}{dx_1}$$

$$S_6 = 2S_{12} \quad \frac{du_2}{dx_1} + \frac{du_1}{dx_2}.$$

A normal strain is positive when extensional, negative when compressional. A shearing stress, and also a shearing strain, is positive when a rectangle becomes deformed so that an acute angle lies in the quadrant between the positive directions of the axes that form the sides of the rectangle.

### 3.3. The Piezoelectric Relations

*3.3.1. General*

When $T_p$ and $E_i$ are chosen as the independent variables, the piezoelectric equations for the most general case (that of a triclinic crystal) are:

$$\begin{aligned}
S_1 &= s^E_{11}T_1+s^E_{12}T_2+s^E_{13}T_3+s^E_{14}T_4+s^E_{15}T_5+s^E_{16}T_6 \quad +d_{11}E_1+d_{21}E_2 \ +d_{31}E_3\\
S_2 &= s^E_{12}T_1+s^E_{22}T_2+s^E_{23}T_3+s^E_{24}T_4+s^E_{25}T_5+s^E_{26}T_6 \quad +d_{12}E_1+d_{22}E_2 \ +d_{32}E_3\\
S_3 &= s^E_{13}T_1+s^E_{23}T_2+s^E_{33}T_3+s^E_{34}T_4+s^E_{35}T_5+s^E_{36}T_6 \quad +d_{13}E_1+d_{23}E_2 \ +d_{33}E_3\\
S_4 &= s^E_{14}T_1+s^E_{24}T_2+s^E_{34}T_3+s^E_{44}T_4+s^E_{45}T_5+s^E_{46}T_6 \quad +d_{14}E_1+d_{24}E_2 \ +d_{34}E_3\\
S_5 &= s^E_{15}T_1+s^E_{25}T_2+s^E_{35}T_3+s^E_{45}T_4+s^E_{55}T_5+s^E_{56}T_6 \quad +d_{15}E_1+d_{25}E_2 \ +d_{35}E_3\\
S_6 &= s^E_{16}T_1+s^E_{26}T_2+s^E_{36}T_3+s^E_{46}T_4+s^E_{56}T_5+s^E_{66}T_6 \quad +d_{16}E_1+d_{26}E_2 \ +d_{36}E_3
\end{aligned} \tag{10}$$

$$\begin{aligned}
D_1 &= d_{11}T_1+d_{12}T_2+d_{13}T_3+d_{14}T_4+d_{15}T_5+d_{16}T_6 \quad +\epsilon^T_{11}E_1+\epsilon^T_{12}E_2+\epsilon^T_{13}E_3\\
D_2 &= d_{21}T_1+d_{22}T_2+d_{23}T_3+d_{24}T_4+d_{25}T_5+d_{26}T_6 \quad +\epsilon^T_{12}E_1+\epsilon^T_{22}E_2+\epsilon^T_{23}E_3\\
D_3 &= d_{31}T_1+d_{32}T_2+d_{33}T_3+d_{34}T_4+d_{35}T_5+d_{36}T_6 \quad +\epsilon^T_{13}E_1+\epsilon^T_{23}E_2+\epsilon^T_{33}E_3
\end{aligned}$$

where $s^E$ is the elastic compliance at constant field-strength, in matrix notation (3.3.8), $\epsilon$ the dielectric permittivity,[7] and $d$ the piezoelectric strain-constant. Rationalized mks units are implied in the equations, and throughout this report, unless otherwise stated. Since, according to the definitions given above, a positive stress is associated with a positive strain, the signs of all terms containing stress differ from those used by Voigt.

[7] The term "permittivity" is synonymous with "capacitivity" as defined in *Standards on Abbreviations, Graphic Symbols, Letter Symbols, and Mathematical Signs, 1948*. The word "permittivity" is adopted for this *Standard* because of its almost universal use in piezoelectric and dielectric theory.

In order to minimize the number of subscripts the well-established symbols $\epsilon_0$ and $K$ are used in this Standard instead of the symbols $\epsilon_r$ and $\epsilon_r$ given in *Standards on Abbreviations*, etc., 1948, referred to above.

The 36 compliance constants $s$ form a matrix relating strain $S$ to stress $T$. In matrix notation this relation may be written $S=s^ET$. Similarly the 18 piezoelectric strain-constants $d$ form a matrix relating $S$ to $E$ or $D$ to $T$. In matrix notation the piezoelectric contributions to $S$ and $D$ are written as $S=d_tE$, $D=dT$, where $d_t$ signifies a transposed matrix.

It will be observed that the $d$-matrix appearing in the first three equations (10) has six rows and three columns, while in the last three equations it has three rows and six columns; in the latter case the rows and columns are interchanged, and the $d$-matrix in the first six equations is a *transposed matrix* with respect to the one having three rows and six columns. The transposed $d$-matrix has the special designation $d_t$. It should be noted that the transposed matrix (three columns) is to be used wherever a piezoelectric constant is associated with an electric vector, the latter being regarded as a matrix with one column and three rows.

*3.3.2. Equations in Voigt's Notation*

Before passing to the formulation that is of chief concern in this report, we give for comparison the four familiar equations of state according to Voigt, in cgs electrostatic units, but with the stress $X$ positive when the strain $x$ is positive, using matrix notation.

$$\begin{aligned}
x &= s^EX + d_tE \qquad X = c^Ex - e_tE\\
P &= dX + \eta^XE \qquad P = ex + \eta^xE
\end{aligned} \quad \text{(not standard)} \tag{11}$$

where $P$ is the polarization, and $\eta^X$ and $\eta^x$ are the dielectric susceptibilities at constant stress and constant strain. The equations for $P$ can be changed to equations for $D$ by multiplying each side by $4\pi$ and then adding $E$. Then, since in esu $1+4\pi\eta=K$, it follows that $D=4\pi dX+K^TE$, and $D=4\pi ex+K^SE$. When these equations, together with those for $x$ and $X$ above, are converted to mks units, with $T$ and $S$ in place of $X$ and $x$, the result is

$$\begin{aligned}
S &= s^ET + d_tE \qquad T = c^ES - e_tE\\
D &= dT + \epsilon^TE \qquad D = eS + \epsilon^SE.
\end{aligned} \tag{12}$$

Here $d$ and $e$ are in rationalized mks units, obtained by dividing the quantities in esu by $3(10^4)$ and $3(10^5)$, respectively. The two equations at the left are the same

as (10) in matrix notation. Those at the right are equivalent to another set of equations similar to (10), but with $S_p$ and $E_i$ as independent variables.

*3.3.3. Recommended Equations of State in Matrix Notation*

In many piezoelectric investigations it is desirable to use as independent variables $S_p$ and $D_i$, or $T_p$ and $D_i$. In these cases the $c$'s and $s$'s should have the superscript $D$ instead of $E$, indicating that they give the relations between stress and strain when $D$ is held constant. Two more sets of equations similar to (10) are needed. In one set, $S$ and $E$ are expressed in terms of $T$ and $D$; in the other set, $T$ and $E$ are expressed in terms of $S$ and $D$.

It is unnecessary to write all these equations in full, since their content can be expressed at once in matrix form, as follows:[8]

$$S = s^D T + g_t D \tag{13}$$

$$E = -gT + \beta^T D \tag{14}$$

$$T = c^D S - h_t D \tag{15}$$

$$E = -hS + \beta^S D \tag{16}$$

For comparison with these expressions, (12) are here repeated:

$$S = s^E T + d_t E \tag{12a}$$

$$D = dT + \epsilon^T E \tag{12b}$$

$$T = c^E S - e_t E \tag{12c}$$

$$D = eS + \epsilon^S E. \tag{12d}$$

In the foreging equations $\epsilon$ is the dielectric permittivity, and $\beta$ is the dielectric impermeability, related to $\epsilon$ as indicated in Tables III and IV. $g$ and $h$ are the piezoelectric constants corresponding to $d$ and $e$. When $d$ and $e$ are in rationalized mks units, as in (12a) to (12d), the relations are:

$$d = \epsilon^T g \qquad e = \epsilon^S h. \tag{17}$$

The superscripts designate the boundary conditions. $s^E$ is the elastic compliance when the electric field is constant or zero (short circuit); $\epsilon^T$ is the permittivity when the stress is constant or zero (free crystal).

Constants without a superscript to designate the thermal conditions, such as $s$, $d$, $\epsilon$, are considered to be those measured under adiabatic conditions. Constants measured isothermally should be designated by a superscript $\theta$.

For greater generality, (12) to (16) could include thermal terms as well as elastic and electric; in that case each coefficient belonging to any one of the three effects (elastic, electric, and thermal) would have to be provided with two superscripts, indicating the boundary conditions with respect to the other two effects. For example, a compliance constant measured adiabatically and at constant displacement would be $s_{ij}{}^{\sigma D}$. In all expressions involving thermal effects the symbol $\sigma$ is to be used for entropy per unit volume, and $\theta$ for absolute temperature. Further consideration of the treatment of thermal effects lies outside the scope of this Standard.

This superscript notation can be extended to mixed boundary conditions. For example, in the important practical case of thickness vibrations, the elastic constant governing the vibration would properly be designated as $c^{E_t D_n}$, indicating that the transverse components of the field $E$ are constant and that the normal component of the displacement $D$ is constant. This is the meaning to attach to $c$ in thickness vibrations, although the superscript may be omitted.

In equations (12) to (16) all symbols denote matrices. $S$ and $T$ are column matrices of 6 terms; $E$ and $D$ column matrices of 3 terms; $e$ and $s$ symmetrical matrices of 6 columns and 6 rows; and $d$, $e$, $g$, $h$, 6 columns and 3 rows; $\epsilon$ and $\beta$, symmetrical matrices of 3 columns and 3 rows.

*3.3.4.* The four piezoelectric constants ($d$, $e$, $g$, and $h$)

TABLE II

| Quantity | Units[5] (mks) | Symbols | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Adopted | (a) Cady | (b) Mason | (c) Wooster | (d) Voigt | (e) Mueller | (f) Baerwald |
| Stress[1] | $N/m^2$ | $T$ | $X_x$ | $X_x$ | $t$ | $X_x$ | $X_x$ | $\sigma$ |
| Strain[1] | | $S$ | $x_x$ | $x_x$ | $r$ | $x_x$ | $x_x$ | $\eta$ |
| Elastic displacement | $m$ | $u$ | | | | | | |
| Sign of tensile stress | | + | − | − | + | − | − | + |
| Electric field strength | $V/m$ | $E$ | $E$ | $E$ | $E$ | $E$ | $E$ | $E$ |
| Electric displacement | $C/m^2$ | $D$ | $D$ | $D$ | $D$ | $D$ | $D$ | $D$ |
| Absolute temperature | | $\theta$ | | | | | | |
| Entropy per unit volume | | $\sigma$ | | | | | | |
| Elastic compliance[2] ($E$ =constant) | $m^2/N$ | $s^E$ | $s^E$ | $s^E$ | $s$ | $s$ | $s$ | $s$ |
| Elastic compliance ($D$ =constant) | $m^2/N$ | $s^D$ | $s^D$ | $s^Q$ | | | | $s$ |
| Elastic stiffness ($E$ =constant) | $N/m^2$ | $c^E$ | $c^E$ | $c^E$ | $c$ | $c$ | | $c$ |
| Elastic stiffness ($D$ =constant) | $N/m^2$ | $c^D$ | $c^D$ | $c^Q$ | | | $c$ | $c$ |
| Permittivity ($T$ =constant) | $F/m$ | $\epsilon^T$ | $k'$ | $K^F$ | | | $\epsilon_F$ | $\epsilon$ |
| Permittivity ($S$ =constant) | $F/m$ | $\epsilon^S$ | $k''$ | $K^C$ | | | | $\epsilon$ |
| Dielectric constant, relative[3] | | $K$ | | | | | | |
| Dielectric impermeability ($T$ =constant) | $m/F$ | $\beta^T$ | $\theta'$ | | | | | $\beta$ |
| Dielectric impermeability ($S$ =constant) | $m/F$ | $\beta^S$ | $\theta''$ | | | | | $\beta$ |
| Dielectric susceptibility ($T$ =constant) | | $\eta^T$ | $\eta'$ | $\kappa$ | $k$ | $\eta$ | $\kappa$ | |
| Dielectric susceptibility ($S$ =constant) | | $\eta^S$ | $\eta''$ | $\kappa^c$ | | $\eta'$ | $\kappa_{cl}$ | |
| Reciprocal susceptibility ($T$ =constant) | | $\chi^T$ | $\chi'$ | $\chi^k$ | | | | |
| Reciprocal susceptibility ($S$ =constant) | | $\chi^S$ | $\chi''$ | $\chi$ | | | $\chi$ | |
| Dielectric polarization | $C/m^2$ | $P$ | $P$ | $P$ | $p$ | $P$ | $P$ | $P$ |
| Piezoelectric strain-constant[4] Eq. (12) | $\frac{C}{N}$ or $\frac{m}{V}$ | $d$ | $d$ | $d$ | $q$ | $d$ | $d$ | $d$ |
| Piezoelectric stress-constant[4] Eq. (12) | $C/m^2$ | $e$ | $e$ | $e$ | $e$ | $e$ | $e$ | $e$ |
| Piezoelectric strain-constant[4] Eq. (14) | $m^2/C$ | $g$ | | $g$ | | | | $h$ |
| Piezoelectric stress-constant[4] Eq (16) | $\frac{N}{C}$ or $\frac{V}{m}$ | $h$ | | $f$ | | | | $g$ |
| Coupling coefficient | | $k$ | | $k$ | | | $k$ | $\kappa$ |

(a) As given in "Piezoelectricity," McGraw-Hill, 1946.
(b) As given in several papers in the *Physical Review*, 1939–1945.
(c) As given "Crystal Physics," Cambridge Univ. Press, 1938.
(d) As given in "Lehrbuch der Kristallphysik," Teubner, 1928.
(e) As given in several papers in the *Physical Review*, 1935–1940.
(f) As given in OSRD Report No. 287, Contract No. OEMsr-120 (1941).

For numbered footnotes see *Explanation of Table II* on page 1394.

[8] The form of the piezoelectric relations in (12) to (16) was first proposed by H. G. Baerwald, in OSRD Report No. 287, Contract No. OEMsr-120, 1941.

are related as indicated above, but each presents a different aspect of the piezoelectric relationship and is useful for a particular set of conditions. For example, $d$ measures the strain in a free crystal for a given applied field, $e$ the stress developed by a given field when the crystal is clamped, $g$ the open circuit voltage for a given stress, and $h$ the open circuit voltage for a given strain.

*3.3.5.* In Table II are listed the symbols adopted for this Standard and also those used by various authors for elastic, electric, and piezoelectric quantities.

*Explanation of Table II. The numbered paragraphs relate to the numerical superscripts in the table.*

1. $X_x$ for stress and $x_x$ for strain indicate that the notation used was $X_x$, $Y_y$, $Z_z$, $Y_z$, $Z_x$, $X_y$ for stress and $x_x$, $y_y$, $z_z$, $y_z$, $z_x$ and $x_y$ for strain; or, alternatively, $X_1 \cdots X_6$ and $x_1 \cdots x_6$.
2. Other superscripts are to be used for other boundary conditions as necessary; *e.g.* for zero polarization or infinite air gap.
3. $\epsilon_0$ is the permittivity of free space. In the electrostatic system $\epsilon_0$ is equal to 1 and $\epsilon = K$, numerically. In the mks system $\epsilon_0 = 8.85 \times 10^{-12}$ farad/meter $= 1/(36\pi \times 10^9)$ farad/meter. See footnote 7.
4. The numbers in parentheses refer to equations (13) to (16) which define the different piezoelectric constants. The piezoelectric constant $f$ was introduced by Mason[9] to designate the ratio of elastic stress to charge-density on the electrodes, in cgs esu. As can be seen from (15), the piezoelectric stress-constant $h$ corresponds to $f$, but represents the ratio of stress to displacement rather than to charge-density. The constants $d$ and $e$ have long been used, following Voigt; $g$ was introduced by Baerwald.[8]
5. The letters referring to the units of the mks system have the following meaning:
   $N$ = newton, the unit of force $= 10^5$ dynes.
   $m$ = meter, the unit of length = 100 centimeters
   $V$ = volt, the unit of potential = 1/300 statvolt
   $C$ = coulomb, the unit of charge $= 3 \times 10^9$ statcoulombs
   $F$ = farad, the unit of capacitance $= 9 \times 10^{11}$ statfarads.

*3.3.6.* The relations among the constants in (13) to (16) are given in matrix notation in Table III. Units are rationalized mks.

TABLE III

$$c^E = (s^E)^{-1} \qquad d = es^E = \epsilon^T g$$
$$c^D = (s^D)^{-1} \qquad e = dc^E = \epsilon^S h$$
$$\beta^T = (\epsilon^T)^{-1} \qquad g = hs^D = \beta^T d$$
$$\beta^S = (\epsilon^S)^{-1} \qquad h = gc^D = \beta^S e$$
$$\epsilon^T - \epsilon^S = dc^E d_t = es^E e_t = de_t$$
$$\beta^S - \beta^T = hs^D h_t = gc^D g_t = hg_t$$
$$c^D - c^E = e_t \beta^S e = h_t \epsilon^S h = h_t e$$
$$s^E - s^D = g_t \epsilon^T g = d_t \beta^T d = d_t g$$

[9] W. P. Mason, "A dynamic measurement of the elastic, electric, and piezoelectric constants of Rochelle Salt," *Phys. Rev.*, vol. 55, pp. 775–789; June, 1939.

Matrices of the $c$, $s$, $d$, $e$, and $\epsilon$ constants applicable to each of the crystal classes except the monoclinic are given by Cady.[10] For the revised forms of the monoclinic matrices see Section 1.4. From the matrices and the relations in Table III the other constants may be obtained.

*3.3.7. Tensor Notation*

In full tensor notation (12) to (16) are written:

$$S_{ij} = s^E_{ijkl} T_{kl} + d_{ijm} E_m \qquad S_{ij} = s^D_{ijkl} T_{kl} + g_{ijm} D_m$$
$$D_n = d_{nkl} T_{kl} + \epsilon^T_{nm} E_m \qquad E_m = -g_{mkl} T_{kl} + \beta^T_{mn} D_n$$
$$T_{kl} = c^E_{ijkl} S_{ij} - e_{klm} E_m \qquad T_{kl} = c^D_{ijkl} S_{ij} - h_{kln} D_n$$
$$D_n = e_{nij} S_{ij} + \epsilon^S_{nm} E_m \qquad E_m = -h_{mij} S_{ij} + \beta^S_{mn} D_n$$

where subscripts repeated in the same term indicate summation. All subscripts take the values 1, 2, 3.

The relations among the constants in tensor notation are given in Table IV. In this Table, $I$ is the idemfactor relating a tensor with its reciprocal.

TABLE IV

$$c^E_{ijpq} s^E_{pqkl} = I_{ijkl} \qquad d_{nkl} = \epsilon^T_{nm} g_{mkl} = e_{nij} s^E_{ijkl}$$
$$c^D_{ijpq} s^D_{pqkl} = I_{ijkl} \qquad e_{nkl} = \epsilon^S_{nm} h_{mkl} = d_{nij} c^E_{ijkl}$$
$$\beta^T_{mp} \epsilon^T_{pn} = I_{mn} \qquad g_{nkl} = \beta^T_{nm} d_{mkl} = h_{nij} s^D_{ijkl}$$
$$\beta^S_{mp} \epsilon^S_{pn} = I_{mn} \qquad h_{nkl} = \beta^S_{nm} e_{mkl} = g_{nij} c^D_{ijkl}$$

$$\epsilon^T_{mn} - \epsilon^S_{mn} = d_{nkl} e_{mkl}$$
$$\beta^S_{mn} - \beta^T_{mn} = h_{nkl} g_{mkl}$$
$$c^D_{ijkl} - c^E_{ijkl} = e_{mij} h_{mkl}$$
$$s^E_{ijkl} - s^D_{ijkl} = d_{mij} g_{mkl}.$$

To obtain explicit relations between the $c_{ijkl}$ and the $s_{ijkl}$ or the $\epsilon_{mn}$ and $\beta_{mn}$ it is necessary to use the matrix relations given in Table III, Section 3.3.6.

*3.3.8.* Since, according to Section 3.2.3, the shearing strain components in the matrix notation (Section 3.3.1) are set equal to twice the tensor strain components (*e.g.*, $S_4 = 2S_{23}$) the numerical values of the tensor components of some of the constants are not equal to the corresponding components in the matrix notation of Section 3.3.3. The relations are given in Table V. The subscripts $i$, $j$, $k$, and $l$ take the values 1, 2 or 3 in all the terms in the Table; $p$ and $q$ take the values given in the first column.

TABLE V

| | | | |
|---|---|---|---|
| when $p, q = 1, 2, 3$ | | | $s_{ijij} = s_{pq}$ |
| $p = 1, 2, 3$, and $q = 4, 5, 6$ | | | $s_{ijjk} = s_{pq}/2$ |
| $p, q = 4, 5, 6$ | | | $s_{ijkl} = s_{pq}/4$ |
| when $p = 1, 2, 3$ | | $d_{iij} = d_{ip}$ | $g_{iij} = g_{ip}$ |
| $p = 4, 5, 6$ | | $d_{ijk} = d_{ip}/2$ | $g_{ijk} = g_{ip}/2$ |

The tensor components of $c$, $e$, and $h$ are equal to the corresponding components in the matrix notation.

*3.3.9. Units*

It is proposed that numerical values of all the quantities involved in the piezoelectric relations be given in

[10] See footnote reference 2.

rationalized mks units. To aid in using these units, factors for converting from cgs electrostatic units to rationalized mks units are given in Table VI.

TABLE VI

CONVERSION FACTORS: *cgs* ELECTROSTATIC TO *mks* (RATIONALIZED) UNITS

The conversion factors are given as dimensionless expressions each equal to unity, except that for $\beta$ and $\eta$ the value is $4\pi$, and for $E$ and $D$, $1/4\pi$. They may be inserted as factors into an equation without changing its validity. Insertion of the appropriate conversion factors into an equation in which cgs electrostatic units are explicit converts the equation to a form which is explicit in mks rationalized units.

| Quantity | Symbol | Conversion Factor | |
|---|---|---|---|
| Mechanical force | $F$ | $10^{-5}$ | newton per dyne |
| Elastic strain | $S$ | 1 | numeric = relative deformation |
| Elastic stress | $T$ | $10^{-1}$ | newton/meter$^2$ per dyne/cm$^2$ |
| Elastic displacement | $u$ | $10^{-2}$ | meter per centimeter |
| Elastic compliance | $s$ | 10 | meter$^2$/newton per cm$^2$/dyne |
| Elastic stiffness | $c$ | $10^{-1}$ | newton/meter$^2$ per dyne/cm$^2$ |
| Electric potential | $V$ | 300 | volt per statvolt |
| Electric field | $E$ | $3\times10^4$ | volt/meter per statvolt/cm |
| Electric charge | $q$ | $\frac{1}{3}\times10^{-9}$ | coulomb per statcoulomb |
| Electric displacement | $D$ | $\frac{1}{12\pi\times10^5}$ | coulomb/meter$^2$ per statcoulomb/cm$^2$ |
| Dielectric permittivity | $\epsilon$ | $\frac{1}{36\pi\times10^9}$ | farad/meter per statfarad/cm |
| Dielectric impermeability | $\beta$ | $36\pi\times10^9$ | meter/farad per cm/statfarad |
| Dielectric constant, relative | $K$ | 1 | numeric $=\epsilon/\epsilon_0$ |
| Dielectric polarization | $P$ | $\frac{1}{3}\times10^{-5}$ | coulomb/meter$^2$ per statcoulomb/cm$^2$ |
| Dielectric susceptibility | $\eta$ | $4\pi$ (numeric) | units (mks) per unit (cgs) |
| Piezoelectric constant | $d$ | $\frac{1}{3}\times10^{-4}$ | coulomb/newton per statcoulomb/dyne |
| Piezoelectric constant | $e$ | $\frac{1}{3}\times10^{-5}$ | coulomb/meter$^2$ per statcoulomb/cm$^2$ |
| Piezoelectric constant | $g$ | $3\times10^5$ | meter$^2$/coulomb per cm$^2$/statcoulomb |
| Piezoelectric constant | $h$ | $3\times10^4$ | newton/coulomb per dyne/statcoulomb |

*Explanation of Table VI*

The conversion factors for $D$, $\epsilon$, $\beta$ and $\eta$ are expressions for either $4\pi$ or $1/4\pi$ instead of unity owing to the differences in definitions of these quantities in rationalized and unrationalized systems, and to the compensating appearance of $4\pi$ explicitly in the equations using these quantities in one system or the other.

The term "permittivity" is synonymous with "capacitivity" as defined in *Standards on Abbreviations, Graphic Symbols, Letter Symbols, and Mathematical Signs, 1948*. The word "permittivity" is adopted for this Standard because of its almost universal use in piezoelectric and dielectric theory.

In order to minimize the number of subscripts the well established symbols $\epsilon_0$ and $K$ are used in this Standard instead of the symbols $\epsilon_v$ and $\epsilon_r$ given in *Standards on Abbreviations*, etc., 1948 referred to above.

In rationalized mks units, polarization and susceptibility, as here defined, are related by the equation $P=\eta\epsilon_0 E$. This convention, though not universally adopted, has the advantage of assigning to $P$ and $\eta$ the same dimensions on both systems of units. It also conforms to good modern usage.[11]

[11] J. A. Stratton, "Electromagnetic Theory," McGraw-Hill Book Co., New York, N. Y., 1941.

*3.3.10. Examples of the Use of Conversion Factors*

The following equation is equally valid whether cgs or mks units are regarded as implicit along with the numerics in the several symbols:

$$E = -gT + \beta^T D.$$

Upon bracketing the symbols when they are intended to represent only the numerics, the equation becomes in cgs units (now shown explicitly)

$$[E]\frac{\text{statvolt}}{\text{cm}} = -[g]\frac{\text{cm}^2}{\text{statcoulomb}}\times[T]\frac{\text{dyne}}{\text{cm}^2} + [\beta^T]\frac{\text{cm}}{\text{statfarad}}\times[D]\frac{\text{statcoulomb}}{\text{cm}^2}.$$

Insert as unit factors, in parentheses, the several conversion factors given in Table VI:

$$[E]\frac{\text{statvolt}}{\text{cm}}\left(\frac{3\times10^4\ \text{volt/meter}}{\text{statvolt/cm}}\right) = -[g]\frac{\text{cm}^2}{\text{statcoulomb}}\left(\frac{3\times10^5\ \text{meter}^2/\text{coulomb}}{\text{cm}^2/\text{statcoulomb}}\right) \times[T]\frac{\text{dyne}}{\text{cm}^2}\left(\frac{10^{-1}\ \text{newton/meter}^2}{\text{dyne/cm}^2}\right) + [\beta^T]\frac{\text{cm}}{\text{statfarad}}\left(\frac{36\pi\times10^9\ \text{meter/farad}}{\text{cm/statfarad}}\right) \times[D]\frac{\text{statcoulomb}}{\text{cm}^2}\left(\frac{\text{coulomb/meter}^2}{12\pi\times10^5\ \text{statcoulomb/cm}^2}\right).$$

After cancelling, and dividing out the factor $3\times10^4$, the equation becomes

$$[E]\frac{\text{volt}}{\text{meter}} = -[g]\frac{\text{meter}^2}{\text{coulomb}}\times[T]\frac{\text{newton}}{\text{meter}^2} + [\beta^T]\frac{\text{meter}}{\text{farad}}\times[D]\frac{\text{coulomb}}{\text{meter}^2},$$

and thus the original equation

$$E = -gT + \beta^T D$$

is seen to be equally valid whether the symbols imply cgs or mks units along with the numerics.

Following are a few numerical examples of conversion of units. They are for ammonium dihydrogen phosphate, based on Mason's measurements.[12]

| | Electrostatic cgs units | | Rationalized mks units | |
|---|---|---|---|---|
| $d_{36}$ | $1.55\times10^{-8}$ | statcoulomb/dyne | $5.17\times10^{-11}$ | coulomb/newton |
| $e_{36}$ | $0.096\times10^6$ | statcoulomb/cm$^2$ | 0.319 | coulomb/meter$^2$ |
| $g_{36}$ | $0.012\times10^{-6}$ | cm$^2$/statcoulomb | 0.375 | meter$^2$/coulomb |
| $h_{36}$ | $0.088\times10^6$ | dyne/statcoulomb | $0.0263\times10^{11}$ | newton/coulomb |

[12] W. P. Mason, "The elastic, piezoelectric, and dielectric constants of potassium dihydrogen phosphate and ammonium dihydrogen phosphate," *Phys. Rev.*, vol. 69, pp. 173–194; March, 1946.

# Response of Circuits to Steady-State Pulses*

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*Summary*—A method of calculating the steady-state response of circuits to repeated pulses is given using the method of the steady-state operational calculus. A short table of transforms which have been found useful in these calculations is also presented. The response of several basic circuits to these pulses is obtained and shown as calculated curves, and the calculated curves are then compared with curves obtained experimentally. These curves have been found to be very useful in adjusting circuits to be used with pulses. Several other possible applications are discussed.

## Introduction

MUCH WORK has been done lately on the manner in which electrical circuits affect the shape of pulses.[1,2,3] MacLachlan[4] and others[5,6,7] have studied the response of circuits to the impulsive type of pulse, i.e., a pulse in which the energy has been transferred to the circuit before the circuit has had time to respond. Very little work on the response of circuits to steady-state pulses of the impulsive type has been done, however, and it is the purpose of this paper to examine this type of response.

## Analysis

When considering the impulsive type of pulse, the main requirement to be satisfied is that the duration of the pulse be much shorter than any of the time constants or natural periods of oscillation of the circuits used. For example, a one-microsecond pulse width should be satisfactory for a circuit whose smallest time constant is of the order of ten microseconds, and whose highest natural frequency is of the order of 100 kc. If the above is satisfied, the shape of the particular pulse used should have very little effect on the results. The area $E$ is a satisfactory measure of the strength of a pulse, and a unit pulse will be defined as one with unit area.

The pulse voltage wave form of Fig. 1(a) has the steady-state direct transform[8]

$$S(e) = \frac{E}{ap}(1 - \epsilon^{-pa}). \tag{1}$$

For very small values of $a$, the transform approaches the impulsive form

$$S(e) = E. \tag{2}$$

In applying the repeated pulses to circuits, a table of steady-state transforms was found very useful, and a short table of this kind is presented in Table I. The symbol $Im_1$ indicates an impulse of the first order and would be that of Fig. 1(a) with $E=1$ and $a$ approaching zero. Similarly $Im_2$ indicates an impulse of the second order and is that of Fig. 1(b) with $E=1$ and $a$ approaching zero. Figs. 1(c) and (d) show impulses of the third and fourth order, i.e., $Im_3$ and $Im_4$.

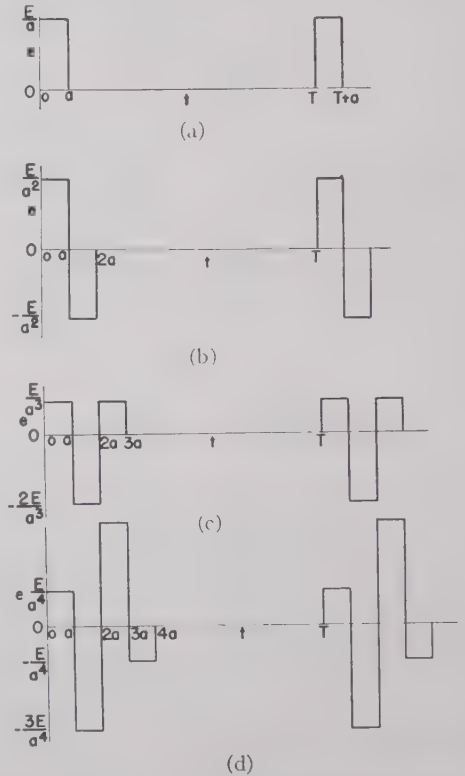


Fig. 1—Wave forms of the voltage pulses of orders (a) one, (b) two, (c) three, (d) four.

## Response of Circuits

In determining the response of circuits to repeated pulses, the first circuit to be considered is that of a resistance $R$ and a capacitance $C$ in series. If the repeated pulses have the direct transform of (2), the direct transform of the current $i$ flowing is

$$S(i) = \frac{E}{R}\,\frac{p}{p + \dfrac{1}{CR}}, \tag{3}$$

and that of the voltages across the resistance $R$ and the capacitance $C$ are

* Decimal classification: R141.3. Original manuscript received by the Institute, February 24, 1949; revised manuscript received, September 26, 1949.

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[1] E. Frank, "Pulsed Linear Networks," McGraw-Hill Book Company, New York, N. Y., 1945.

[2] E. C. Cherry, "Pulse response," *Jour. I.E.E.*, pt. III, vol. 92, pp. 183–196; September, 1945.

[3] G. N. Glasoe, and J. V. Lebacqz, "Pulse Generators," McGraw-Hill Book Company, New York, N. Y., 1948.

[4] McLachlan, "Operational form of $f(t)$ for a finite interval with application to impulses," *Phil. Mag.*, vol. 26, Ser. 7/ pp. 695–704; November, 1938.

[5] M. F. Gardner, and J. L. Barnes, "Transients in Linear Systems," John Wiley and Sons, Inc., New York, N. Y., pp. 252–263; 1942.

[6] G. A. Campbell and R. M. Foster, "Fourier Integrals for Practical Applications," D. Van Nostrand Co., New York, N. Y., pp. 15–19; 1942.

[7] J. C. Jaeger, "Switching problems and instantaneous impulses," *Phil. Mag.*, vol. 36, Ser. 7, pp. 644–651; September, 1945.

[8] D. L. Waidelich, "Steady-state operational calculus," PROC. I.R.E., vol. 34, pp. 78–83; February, 1946.

TABLE I

STEADY-STATE TRANSFORM TABLE

| *Direct Transform* $S[f(t)] = F(p)$ | *Inverse Transform* $S^{-1}[F(p)] = f(t)$ |
|---|---|
| 1. $1$ | $Im_1$ |
| 2. $p$ | $Im_2$ |
| 3. $p^n$ | $Im_{(n+1)}$ |
| 4. $\dfrac{1}{p+a}$ | $\dfrac{\epsilon^{-a}}{1-\epsilon^{-aT}}$ |
| 5. $\dfrac{p}{p+a}$ | $-a\dfrac{\epsilon^{-at}}{1-\epsilon^{-aT}} + Im_1$ |
| 6. $\dfrac{1}{p^2+a^2}$ | $\dfrac{T}{2m}\dfrac{\cos m\left(\dfrac{t}{T}-\dfrac{1}{2}\right)}{\sin (m/2)}$ where $m = aT$ |
| 7. $\dfrac{p}{p^2+a^2}$ | $-\dfrac{\sin m\left(\dfrac{t}{T}-\dfrac{1}{2}\right)}{2\sin (m/2)}$ where $m = aT$ |
| 8. $\dfrac{p^2}{p^2+a^2}$ | $-\dfrac{m}{2T}\dfrac{\cos m\left(\dfrac{t}{T}-\dfrac{1}{2}\right)}{\sin (m/2)} + Im_1$ where $m = aT$ |
| 9. $\dfrac{1}{(p+a)^2}$ | $\dfrac{\epsilon^{-a(t-T)}[t-\epsilon^{-aT}(t-T)]}{2(\cosh aT-1)}$ |
| 10. $\dfrac{p}{(p+a)^2}$ | $\dfrac{\epsilon^{-a(t-T)}}{2(\cosh aT-1)}[(1-at)(1-\epsilon^{-aT}) - aT\epsilon^{-aT}]$ |
| 11. $\dfrac{p^2}{(p+a)^2}$ | $\dfrac{\epsilon^{-a(t-T)}}{2(\cosh aT-1)}[a(at-2)(1-\epsilon^{-aT}) + a^2T\epsilon^{-aT}] + Im_1$ |
| 12. $\dfrac{1}{(p+\alpha_1)(p+\alpha_2)} = \dfrac{1}{(p+a)^2-b^2} = \dfrac{1}{(p+a)^2+\beta^2}$<br>$\alpha_1 = a+b = a+j\beta$<br>$\alpha_2 = a-b = a-j\beta$<br>$b = j\beta \neq 0$ | $\dfrac{1}{(\alpha_2-\alpha_1)}\left[\dfrac{\epsilon^{-\alpha_1 t}}{1-\epsilon^{-\alpha_1 T}} - \dfrac{\epsilon^{-\alpha_2 t}}{1-\epsilon^{-\alpha_2 T}}\right]$<br>$= \dfrac{\epsilon^{-a(t-T)}}{2b}\left[\dfrac{\sinh bt - \epsilon^{-aT}\sinh b(t-T)}{\cosh aT - \cosh bT}\right]$<br>$= \dfrac{\epsilon^{-a(t-T)}}{2\beta}\left[\dfrac{\sin \beta t - \epsilon^{-aT}\sin \beta(t-T)}{\cosh aT - \cos \beta T}\right]$ |
| 13. $\dfrac{p}{(p+\alpha_1)(p+\alpha_2)} = \dfrac{p}{(p+a)^2-b^2} = \dfrac{p}{(p+a)^2+\beta^2}$<br>$\alpha_1 = a+b = a+j\beta$<br>$\alpha_2 = a-b = a-j\beta$<br>$b = j\beta \neq 0$<br>when $b > a$, $\phi = \tanh^{-1}\dfrac{a}{b}$<br>when $a > b$, $\psi = \tanh^{-1}\dfrac{b}{a}$<br>$\sigma = \tan^{-1}\dfrac{a}{\beta}$ | $\dfrac{1}{(\alpha_2-\alpha_1)}\left[\dfrac{-\alpha_1\epsilon^{-\alpha_1 t}}{1-\epsilon^{-\alpha_1 T}} + \dfrac{\alpha_2\epsilon^{-\alpha_2 t}}{1-\epsilon^{-\alpha_2 T}}\right]$<br>$= \dfrac{\epsilon^{-a(t-T)}\sqrt{b^2-a^2}}{2b}\left\{\dfrac{\cosh (bt-\phi) - \epsilon^{-aT}\cosh [b(t-T)-\phi]}{\cosh aT - \cosh bT}\right\}$<br>$= \dfrac{\epsilon^{-a(t-T)}\sqrt{a^2-b^2}}{2b}\left\{\dfrac{-\sinh (bt-\psi) + \epsilon^{-aT}\sinh [b(t-T)-\psi]}{\cosh aT - \cosh bT}\right\}$<br>$= \dfrac{\epsilon^{-a(t-T)}\sqrt{a^2+\beta^2}}{2\beta}\left\{\dfrac{\cos (\beta t+\sigma) - \epsilon^{-aT}\cos [\beta(t-T)+\sigma]}{\cosh aT - \cosh bT}\right\}$ |

TABLE I—(*continued*)

| *Direct Transform* $S[f(t)] = F(p)$ | *Inverse Transform* $S^{-1}[F(p)] = f(t)$ |
|---|---|
| 14. $\dfrac{p^2}{(p+\alpha_1)(p+\alpha_2)} = \dfrac{p^2}{(p+a)-b^2} = \dfrac{p^2}{(p+a)^2+\beta^2}$<br>$\alpha_1 = a+b = a+j\beta$<br>$\alpha_2 = a-b = a-j\beta$<br>$b = j\beta \neq 0$<br>$\rho = \tanh^{-1}\left(\dfrac{2ab}{a^2+b^2}\right)$<br>$\delta = \tan^{-1}\left(\dfrac{2a\beta}{a^2-\beta^2}\right)$ | $\dfrac{1}{(\alpha_2-\alpha_1)}\left[\dfrac{\alpha_1^2\epsilon^{-\alpha_1 t}}{1-\epsilon^{-\alpha_1 T}} - \dfrac{\alpha_2^2\epsilon^{-\alpha_2 t}}{1-\epsilon^{-\alpha_2 T}}\right] + Im_1$<br>$= \dfrac{\epsilon^{-a(t-T)}\left\lvert a^2-b^2\right\rvert}{2b}\left\{\dfrac{\sinh(bt-\rho) - \epsilon^{-aT}\sinh\left[b(t-T)-\rho\right]}{\cosh aT - \cosh bT}\right\} + Im_1$<br>$= \dfrac{\epsilon^{-a(t-T)}(a^2+\beta^2)}{2\beta}\left\{\dfrac{\sin(\beta t-\delta) - \epsilon^{-aT}\sin\left[\beta(t-T)-\delta\right]}{\cosh aT - \cos \beta T}\right\} + Im_1$ |

$$S(e_R) = E\frac{p}{p+\dfrac{1}{CR}} \tag{4}$$

and

$$S(e_C) = \frac{E}{RC}\cdot\frac{1}{p+\dfrac{1}{CR}}. \tag{5}$$

By the use of transforms 4 and 5 of Table I and putting $\theta = (RC/T)$ and $\tau = (t/T)$, where $0<\tau<1$,

$$i = \frac{E}{R}\left[-\frac{\epsilon^{-\tau/\theta}}{\theta T(1-\epsilon^{-1/\theta})} + Im_1\right], \tag{6}$$

$$e_R = E\left[\frac{\epsilon^{-\tau/\theta}}{\theta T(1-\epsilon^{-1/\theta})} + Im_1\right]. \tag{7}$$

and

$$e_C = \frac{E}{RC}\cdot\frac{\epsilon^{-\tau/\theta}}{1-\epsilon^{-1/\theta}}. \tag{8}$$

The current $i$ and the voltage across the resistance $e_R$ have the same shape, and this shape is shown in Fig. 2 for various values of $\theta$. The parameter $\theta$ is equal to the time constant of the circuit divided by the period of the applied pulses, so a larger time constant in the circuit is indicated by a larger value of $\theta$ for a given pulse period. The pulses of Fig. 2 are shown with a finite height which is as they would appear in a practical case. For low values of $\theta$, the circuit approaches a differentiating circuit, and the wave form of Fig. 2 approaches the derivative of the impulse wave form which is an impulse of the second order. Experimental confirmation of the wave form for $\theta = 1$ is shown in Fig. 3, but only the tops of the pulses are visible in the photograph. The wave forms of the voltage $e_C$ across the capacitance are shown in Fig. 4, and it should be noted that no pulses appear in this case. For large values of $\theta$, the circuit approaches an integrating circuit, and the wave form of Fig. 4 ap-

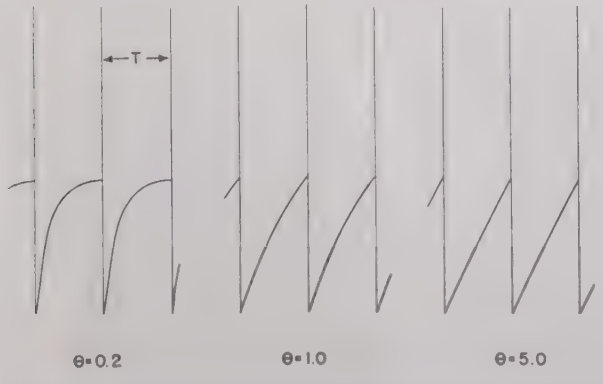


Fig. 2—Calculated wave forms for $e_R$ in a series $RC$ circuit.

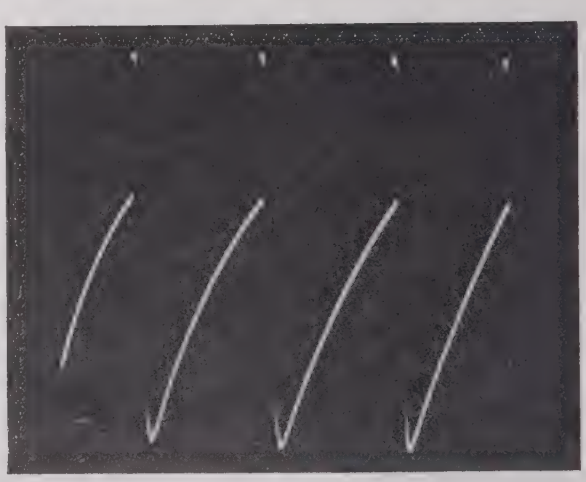

Fig. 3—Experimental wave form for $e_R(\theta = 1.0)$ in a series $RC$ circuit.

Fig. 4—Calculated wave forms for $e_C$ in a series $RC$ circuit.

proaches the integral of the pulse wave minus its average value, resulting in the saw-tooth wave shown. Again, the experimental wave form for $\theta = 1.0$ is shown in Fig. 5.

A number of other circuits have responses which are the same as those of a series resistance-capacitance circuit. Among these are series resistance-inductance, parallel resistance-capacitance, and parallel resistance-inductance circuits. The applied pulses for the parallel circuits are current pulses.

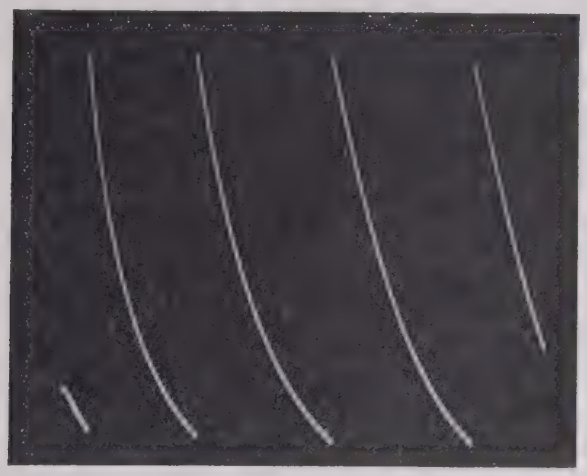

Fig. 5—Experimental wave form for $e_C(\theta = 1.0)$ in a series $RC$ circuit.

Another circuit that is very commonly used is that of an inductance in series with a capacitance. The resistance is assumed zero, although it will be considered different from zero later on. The direct transforms of the current $i$, the voltage $e_L$ across the inductance, and the voltage $e_C$ across the capacitance are

$$S(i) = \frac{E}{L} \frac{p}{p^2 + \frac{1}{LC}} \tag{9}$$

$$S(e_L) = E \frac{p^2}{p^2 + \frac{1}{LC}} \tag{10}$$

and

$$S(e_C) = \frac{E}{LC} \frac{1}{p^2 + \frac{1}{LC}}. \tag{11}$$

By the use of transforms 6, 7, and 8 of Table I and putting $m = (T/\sqrt{LC})$ and $\tau = (t/T)$ where $0 < \tau < 1$,

$$i = -\frac{E}{2L} \frac{\sin m(\tau - 1/2)}{\sin (m/2)}, \tag{12}$$

$$e_L = E\left[-\frac{m \cos m(\tau - 1/2)}{2T \sin (m/2)} + Im_1\right], \tag{13}$$

and

$$e_C = \frac{ET \cos m(\tau - 1/2)}{2m \sin (m/2)}. \tag{14}$$

The current $i$ is shown in Fig. 6 for various values of $m$, and it should be noticed that $(m/2\pi)$ is the number of cycles of the natural frequency of oscillation which occur during one period of the applied pulses. When $m = 2n\pi$ where $n$ is a positive integer, the circuit is resonant at the $n$th harmonic of the applied pulse wave, and since the resistance in the circuit is assumed zero, the response becomes infinitely large. When $m$ becomes very small, the current wave form is the integral of the applied pulse wave form and is similar to that of Fig. 4 for the case of $\theta$ very large. The corresponding wave forms for the inductance voltage $e_L$ are shown in Fig. 7.

Fig. 6—Calculated wave forms for the current in a series $LC$ circuit.

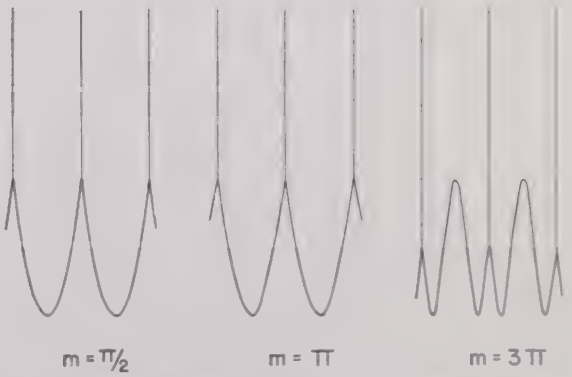


Fig. 7—Calculated wave forms for $e_L$ in a series $LC$ circuit.

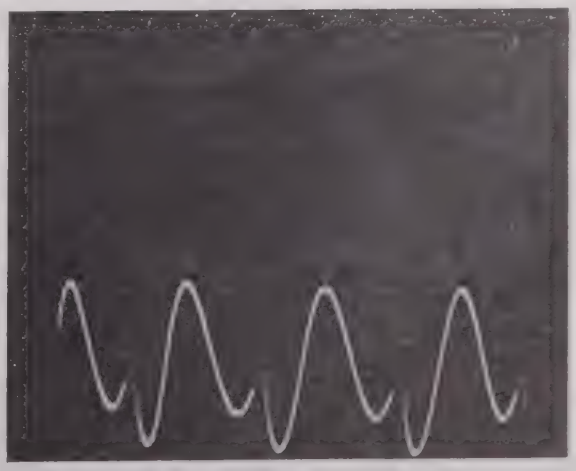

Fig. 8—Experimental wave form for $e_L(m = 3\pi)$ in a series $LC$ circuit.

and the experimental wave for $m=3\pi$ is given in Fig. 8. The effect of resistance in the circuit may be noticed in that the peaks of the natural oscillation of the circuit voltage decrease in height with time. Similar results for the capacitive voltage $e_C$ are shown in Fig. 9. For very low values of $m$ the capacitive voltage approaches the second integral of the applied pulse voltage, which is a parabola. The paralleled inductance and capacitance circuit with a current-pulse wave form applied to it has wave forms exactly similar to those discussed above for the series inductance-capacitance circuit.

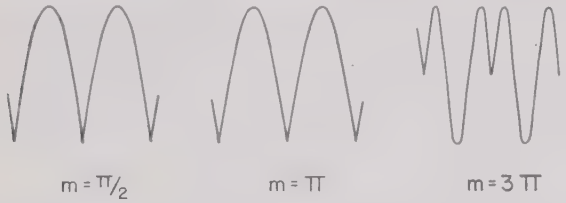


Fig. 9—Calculated wave forms for $e_C$ in a series $LC$ circuit.

When the resistance is not negligibly small in a series resistance-inductance-capacitance circuit, the response differs largely, depending upon whether the resistance is small or large. From transforms 12, 13, and 14 of Table I and with

$$\tau = (t/T), \qquad 0 < \tau < 1,$$

$$\alpha_1 = \left[\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}\right]T, \quad \text{and}$$

$$\alpha_2 = \left[\frac{R}{2L} - \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}\right]T,$$

$$e_R = Ri = \frac{RE}{L(\alpha_2 - \alpha_1)}\left[\frac{-\alpha_1\epsilon^{-\alpha_1\tau}}{1-\epsilon^{-\alpha_1}} + \frac{\alpha_2\epsilon^{-\alpha_2\tau}}{1-\epsilon^{-\alpha_2}}\right], \tag{15}$$

$$e_L = \frac{E}{T(\alpha_2 - \alpha_1)}\left[\frac{\alpha_1^2\epsilon^{-\alpha_1\tau}}{1-\epsilon^{-\alpha_1}} - \frac{\alpha_2^2\epsilon^{-\alpha_2\tau}}{1-\epsilon^{-\alpha_2}}\right] + \frac{EIm_1}{T}, \tag{16}$$

$$e_C = \frac{ET}{LC(\alpha_2 - \alpha_1)}\left[\frac{\epsilon^{-\alpha_1\tau}}{1-\epsilon^{-\alpha_1}} - \frac{\epsilon^{-\alpha_2\tau}}{1-\epsilon^{-\alpha_2}}\right]. \tag{17}$$

This is the nonoscillatory case ($R>2\sqrt{L/C}$), and a typical set of response curves are shown in Fig. 10 for the parameters $\alpha_1=2.0$ and $\alpha_2=1.0$. The shapes of the curves for $e_R$ and $e_L$ resemble those of a series resistance-inductance circuit, as evidenced in Figs. 2 and 4. The voltage $e_C$ across the capacitance, on the other hand, resembles the capacitive voltage of a series inductance-capacitance circuit as given in Fig. 9.

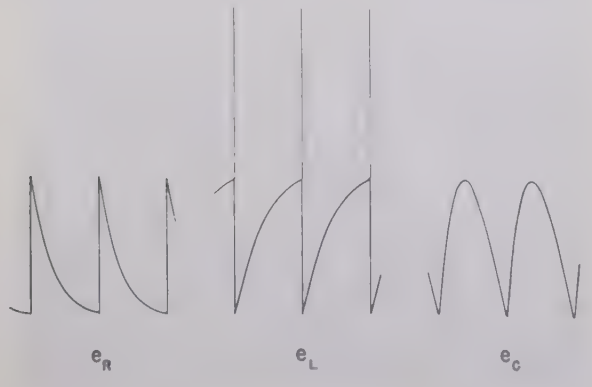


Fig. 10—Calculated wave forms for $e_R$, $e_L$, and $e_C$ in a series $RLC$ circuit with $R>2\sqrt{L/C}$.

The oscillatory case ($R<2\sqrt{L/C}$) is obtained also from transforms 12, 13, and 14 of Table I. If $\tau=(t/T)$, $0<\tau<1$,

$$m = T\sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}, \qquad n = (TR/2L),$$

$$\sigma = \tan^{-1}(n/m), \quad \text{and} \quad \delta = \tan^{-1}\left(\frac{2mn}{n^2 - m^2}\right),$$

$$e_R = Ri = \frac{RE\epsilon^{-n(\tau-1)}\sqrt{m^2+n^2}}{L2m(\cosh n - \cos m)}\{\cos(m\tau+\sigma) - \epsilon^{-n}\sin[m(\tau-1)+\sigma]\}, \tag{18}$$

$$e_L = \frac{E\epsilon^{-n(\tau-1)}(m^2+n^2)}{2mT(\cosh n - \cos m)}\{\sin(m\tau-\delta) - \epsilon^{-n}\sin[m(\tau-1)-\delta]\} + \frac{EIm_1}{T}, \tag{19}$$

$$e_C = \frac{ET\epsilon^{-n(\tau-1)}}{2LCm(\cosh n - \cos m)}\{\sin m\tau - \epsilon^{-n}\sin m(\tau-1)\}. \tag{20}$$

A typical set of response curves for the case $m=3\pi$, $n=1.0$ is shown in Fig. 11. It should be noticed that the curves are very similar to those of Figs. 6, 7, and 9, except that the effect of the additional resistance is to damp out the oscillations. The responses of many other circuits may be obtained by using linear combinations of the transforms given in Table I.

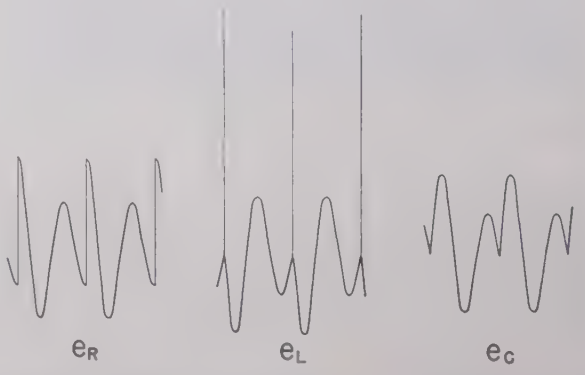


Fig. 11—Calculated wave forms for $e_R$, $e_L$, and $e_C$ in a series $RLC$ circuit with $R<2\sqrt{L/C}$.

In applying the above wave forms to the testing of amplifiers,[9,10] the pulse-generator output is applied to

[9] L. B. Arguimbau, "Network testing with square waves," *Gen. Rad. Exp.*, vol. 14, pp. 1–6; December, 1939.
[10] D. L. Waidelich, "Steady-state testing with saw-tooth waves," Proc. I.R.E., vol. 32, pp. 339–348; June, 1944.

the amplifier, and the output of the amplifier is viewed on an oscilloscope screen. The frequency of the pulse generator may be varied to determine the width of the pass band of the amplifier and the type of distortion present at the edges of the pass band. For example, a simple resistance-capacitance coupled amplifier at low frequencies acts much like a series resistance-capacitance circuit with the output voltage appearing across the resistance. The resulting wave forms are similar then to those of Fig. 2, and the approximate lower half-power frequency would be that when the wave form for $\theta=(1/2\pi)$ of Fig. 12(a) would appear. The upper half-power frequency may be obtained in a similar manner, and the wave form to be used is that of Fig. 12(b) for $\theta=2\pi$. Resonance occurring in the amplifier may be found by noticing for what frequencies of the pulse generator the output voltage becomes very large. The output voltage wave forms should be similar to those of Fig. 9. When the sinusoidal or nearly sinusoidal wave form is that for $m=2\pi$, the frequency of the pulse generator is the same as the resonant frequency of the amplifier.

It has been shown[10] that if the steady-state response of an amplifier is known to a saw-tooth wave of period $T$, the steady-state response to any nonsinusoidal wave of the same period $T$ may be calculated. The same is true if a pulse wave is used. For example, if $e_0(t)$ is the steady-state output response voltage of a pulse of period $T$ applied to an amplifier, and if $e(t)$ is any other non-

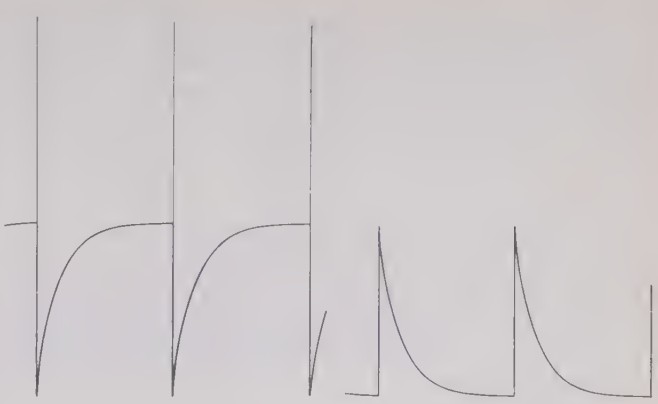

Fig. 12—Calculated wave forms for (a) the lower, (b) the upper half-power frequencies.

sinusoidal wave of period $T$, then the steady-state response $e_s$ of the amplifier to $e(t)$ is

$$e_s = \int_0^T e(t-\tau)e_0(\tau)d\tau, \tag{21}$$

or another equivalent form is

$$e_s = \int_{t-T}^{t} e(\tau)e_0(t-\tau)d\tau. \tag{22}$$

If the equations for $e$ and $e_0$ are known, it is possible to integrate (21) or (22). If equations are not known for either $e$ or $e_0$ or both, a numerical solution is still possible as outlined in the previous reference.[10]

# Diode Phase-Discriminators*

R. H. DISHINGTON†

*Summary*—**Two sinusoidal phase-discriminators are analyzed and it is found that universal curves of their general phase characteristics can be plotted as a function of two parameters. From these curves it is concluded that the resistances in series with the tubes and also the tube resistances themselves are the most important factors in determining optimum performance.**

## Introduction

THE PHASE-DISCRIMINATOR, otherwise known as phase-comparator or phase-detector gives a measurement of the phase difference between two waves. Diode discriminators, having the advantage of simplicity, indicate the phase angle by a voltage at the output terminals. At present, the principles of operation are well known, but there is a noticeable lack of an accurate analysis of the circuits.[1,2] The present paper deals with the problem by applying a recently introduced general method of diode circuit analysis.[3] For all practical purposes, this gives an exact solution. The circuits' general characteristics are given graphically, and only a simple calculation must be made to obtain the complete phase-characteristic for any practical values of the circuit parameters.

## The Basic Method

In footnote reference 3 it was shown that a tube and any series resistance $R_s$ have a *combination characteristic*

$$i_b = Ke_d^{\alpha_c} \tag{1}$$

where $i_b$ is the plate current, $e_d$ is the voltage across both the tube and $R_s$, and $K$ and $\alpha_c$ are constants. Mathematically,

$$e_d = e_b + i_bR_s \tag{2}$$

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[1] W. L. Emery, "Ultra-High-Frequency Radio Engineering," Macmillan Co., New York, N. Y., 1944; p. 41.

[2] L. I. Farren, "Phase detectors, some theoretical and practical aspects," *Wireless Eng.*, vol. 23, pp. 330–340; December, 1946.

[3] R. H. Dishington, "Diode circuit analysis," *Elec. Eng.*, vol. 67, pp. 1043–1049; November, 1948.

where $e_b$ is the plate voltage of the tube. To use the solutions presented further on, two quantities must be computed. First, referring to Figs. 1 and 5,

$$i_2 = \frac{e_{1\max}}{R_{bb}} \tag{3}$$

and, from (2),

$$E_{21} = e_b]_{i_2} + i_2 R_s \tag{4}$$

where $e_b]_{i_2}$ is the plate voltage of the tube at $i_2$, taken directly off the static plate characteristic. Second, the exponent $\alpha_c$ can be found very simply, as explained in footnote reference 3.

### The Simple Sinusoidal Phase-Discriminator

Phase difference between two sinusoidal waves can be measured by the circuit in Fig. 1. The magnitudes of the *open circuit* input voltages $e_x$ and $e_y$ are assumed

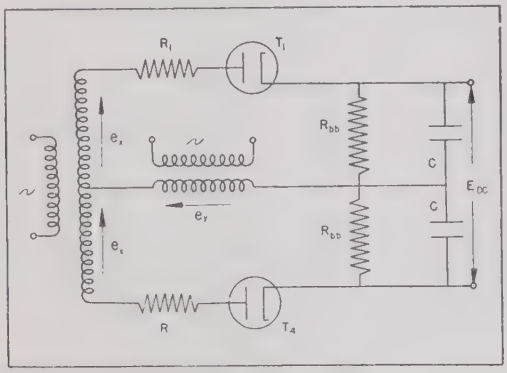


Fig. 1—The simple phase-discriminator.

equal. Both sides of the circuit are identical except for the net voltage applied to each. The driving voltages for $T_1$ and $T_4$ respectively are

$$\left.\begin{aligned} e_1 &= e_y + e_x \\ e_4 &= e_y - e_x \end{aligned}\right\}. \tag{5}$$

Adding a fixed lead of $\pi/2$ to $e_y$, to resolve the ambiguity in $\phi$ for positive and negative angles,

$$\left.\begin{aligned} e_1 &= E\sin\left(\omega t + \phi + \frac{\pi}{2}\right) + E\sin\omega t \\ e_4 &= E\sin\left(\omega t + \phi + \frac{\pi}{2}\right) - E\sin\omega t \end{aligned}\right\}. \tag{6}$$

Transforming (6),

$$\left.\begin{aligned} e_1 &= (e_{1\max})\sin\left(\omega t + \phi + \frac{\pi}{4}\right) \\ e_4 &= (e_{4\max})\cos\left(\omega t + \phi + \frac{\pi}{4}\right) \end{aligned}\right\} \tag{7}$$

where

$$\left.\begin{aligned} e_{1\max} &= 2E\cos\left(\frac{\phi}{2} + \frac{\pi}{4}\right) \\ e_{4\max} &= 2E\sin\left(\frac{\phi}{2} + \frac{\pi}{4}\right) \end{aligned}\right\}. \tag{8}$$

The peak values of $e_1$ and $e_4$ are functions of $\phi$, but not of time.

Equation (7) reveals that the voltages applied to the two opposite sides of the circuit are always 90° out of phase. This means that, except for a short period of overlap, one tube conducts while the other does not. Little error is introduced if both halves are assumed completely independent. Once this assumption is made, reduction to the equivalent circuit is simple, each half of the circuit being reduced separately. The calculated output of $T_4$ is then subtracted from that of $T_1$ to give $E_{DC}$ (Fig. 1). Completely general curves for the solution are shown in Figs. 2, 3, and 4. To use the curves, it is necessary to evaluate $R_s$. In the present circuit, $R_s$ is the sum of the internal resistances of $e_x$ and $e_y$ plus $R_1$. The curves are plotted for various values of the ratio $(E_{21}/e_{1\max})_{-90°}$ at $\phi = -90°$. Actually $E_{21}/e_{1\max}$ changes with $\phi$. A correction for this is used to obtain the solution. The results give $E_{DC}/E$ for negative values of $\phi$, but the positive angles give the same shape of characteristic with negative voltage.

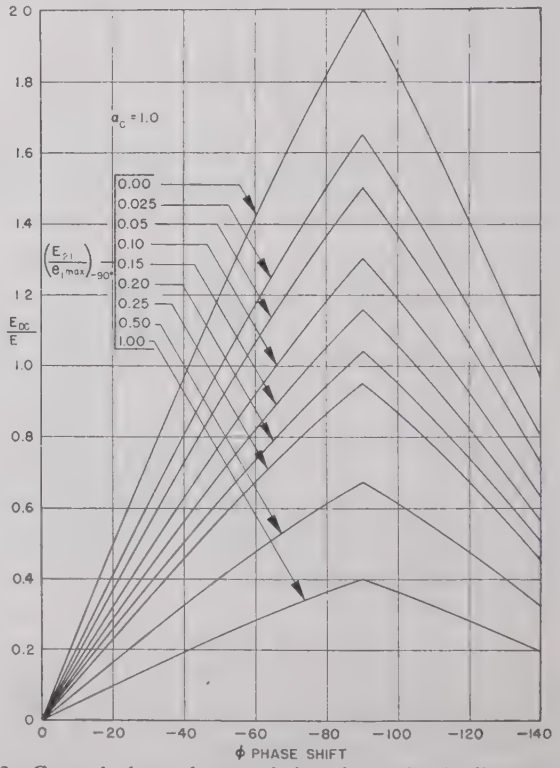


Fig. 2—General phase characteristics of the simple discriminator with sinusoidal input when $\alpha_c = 1.0$. To find $(E_{21}/e_{1\max})$ use the one value $e_{1\max} = 2E$.

The sensitivity of phase measurement for any given value of $\alpha_c$ is a function of $E_{21}/e_{1\max}$, which can be expressed

$$\frac{E_{21}}{e_{1\max}} = \frac{1}{R_{bb}}\frac{e_b}{i_2}\Big]_{i_2} + \frac{R_s}{R_{bb}}. \tag{9}$$

Equation (9) makes it apparent that large values of $R_{bb}$ and small values of $R_s$ tend to lower $E_{21}/e_{1\max}$ and thereby increase the sensitivity. The quantity $e_b/i_2]_{i_2}$ is of the order of magnitude of $R_{T_2}$, so a low $R_{T_2}$ also in-

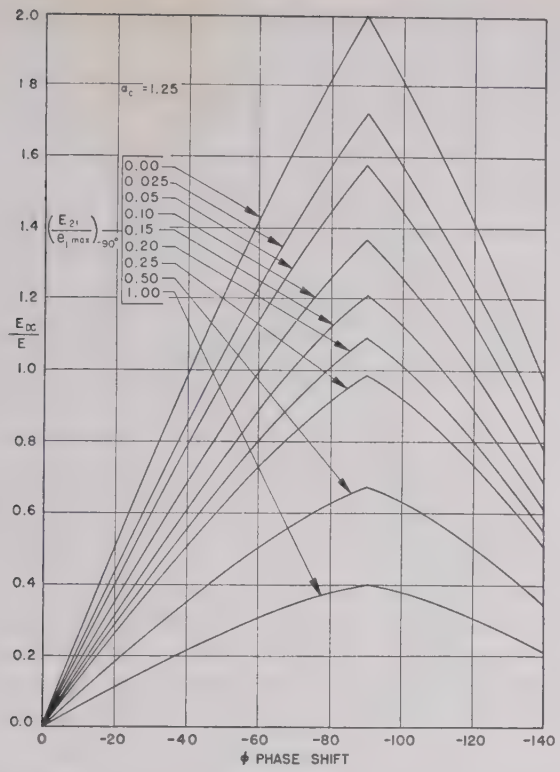


Fig. 3—General phase characteristics of the simple discriminator with sinusoidal input when $\alpha_c = 1.25$. To find $(E_{21}/e_{1\,max})$ use the one value $e_{1\,max} = 2E$.

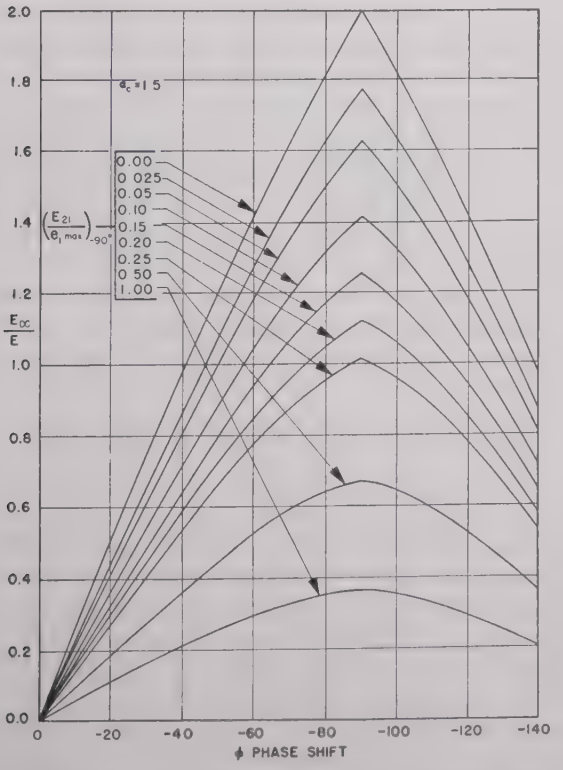


Fig. 4—General phase characteristics of the simple discriminator with sinusoidal input when $\alpha_c = 1.5$. To find $(E_{21}/e_{1\,max})$ use the one value $e_{1\,max} = 2E$.

creases the sensitivity. (For values of $R_{T_g}$ see footnote reference 3.)

The linearity is better for values of $\alpha_c$ near 1.0. However, unless the tube $\alpha_s$ is originally near unity, $\alpha_c$ can only be made linear by adding $R_1$. From the foregoing, this increases $R_s$ and decreases the sensitivity. For high sensitivity, the difference in nonlinearity of the output between $\alpha_c = 1.0$ and $\alpha_c = 1.5$ is very small. Therefore, an optimum design will have no $R_1$, making $R_s$ as small as possible.

### The Balanced Sinusoidal Phase Discriminator

Another well-known comparator is the balanced circuit shown in Fig. 5. The tubes and resistors $R_1$ are the same for each branch. Both $RC$ loads are also similar. Given the same conditions for $e_x$ and $e_y$, the driving

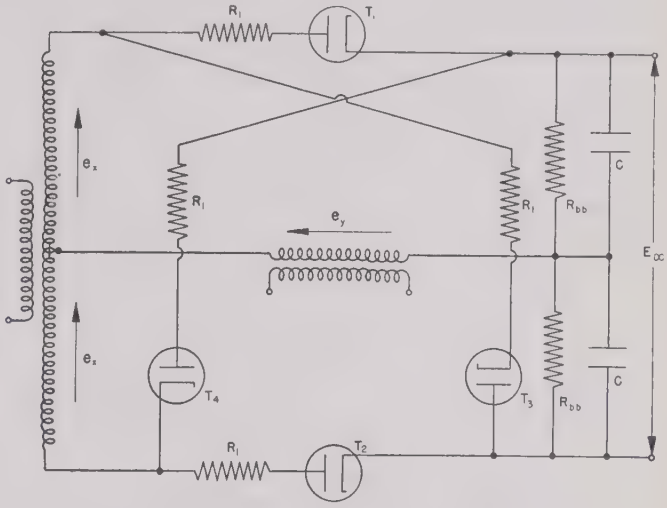


Fig. 5—The balanced phase-discriminator.

voltages for tubes $T_1$, $T_2$, $T_3$, and $T_4$ are $e_1$, $e_4$, $-e_1$, and $-e_4$ respectively. Again, except for a slight overlap, each tube conducts when the other three do not. Consequently, it is assumed that the two halves of the circuit are separable. It is conventional to show $E_{bb}$ as positive with respect to the reference diode plate. Tube $T_1$ is chosen as the reference for the top half, and inasmuch as the constant output voltage is actually produced across an $RC$ load, $E_{bb}$ will be negative for negative phase angles. For the same conditions, $E_{bb}$ tends to make the plate of $T_4$ positive. For this reason, it is important in the derivation to remember that for negative $\phi$, $T_1$ operates class C and $T_4$ operates class AB or A. The second half of the circuit produces an output indentical to the first and in series with it. Thus, the two output voltages are added to give the total $E_{DC}$. The final solution for sinusoidal input voltages is given in Figs. 6, 7, and 8. Remarks on how to calculate $(E_{21}/e_{1\max})_{-90°}$ are exactly the same for this circuit as for the simple comparator. Also the effects of the various resistors on the sensitivity are the same as before. Examining the curves, it appears that unless the flat-topped phase characteristic of Fig. 6 is desired for some particular reason, better sensitivity with more over-all performance is obtained with operation as near to $\alpha_c = 1.5$ as possible. This means less $R_1$; but a precaution is necessary here. Originally, it was assumed that $E_{bb}$ had a constant value for each $\phi$. This is made

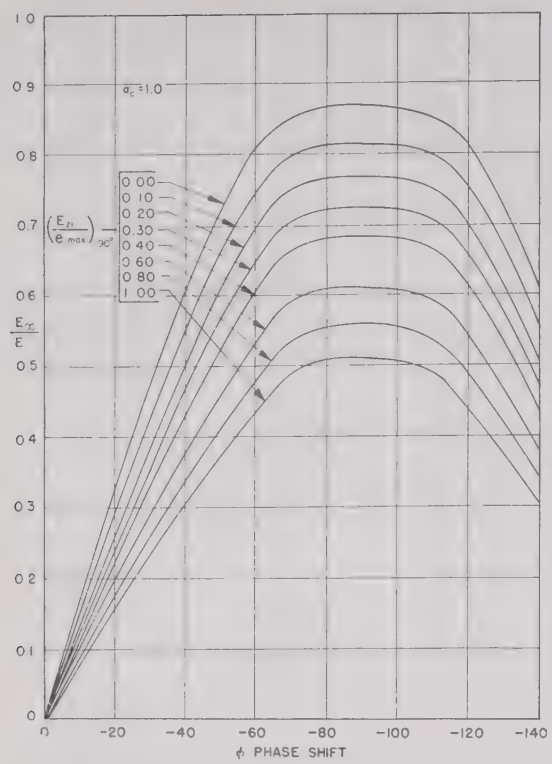


Fig. 6—General phase characteristics of the balanced discriminator with sinusoidal input when $\alpha_c=1.0$. To find $(E_{21}/e_{1\ max})$ use the one value $e_{1\ max}=2E$.

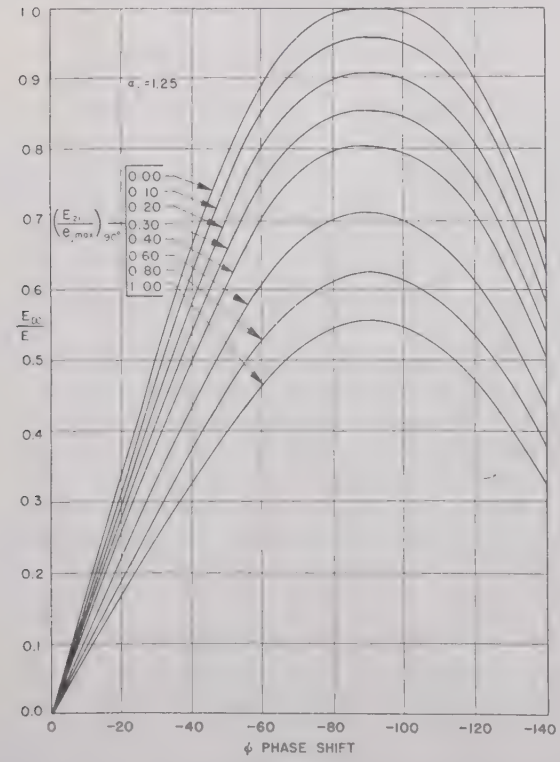


Fig. 7—General phase characteristics of the balanced discriminator with sinusoidal input when $\alpha_c=1.25$. To find $(E_{21}/e_{1\ max})$ use the one value $e_{1\ max}=2E$.

possible by a large enough time constant $R_{bb}C$. Now, however, the capacitor can discharge through $T_4$ for example, and unless $(R_s+R_T)C$ is large, $E_{bb}$ may not remain constant. This generally means that some $R_1$ must be added.

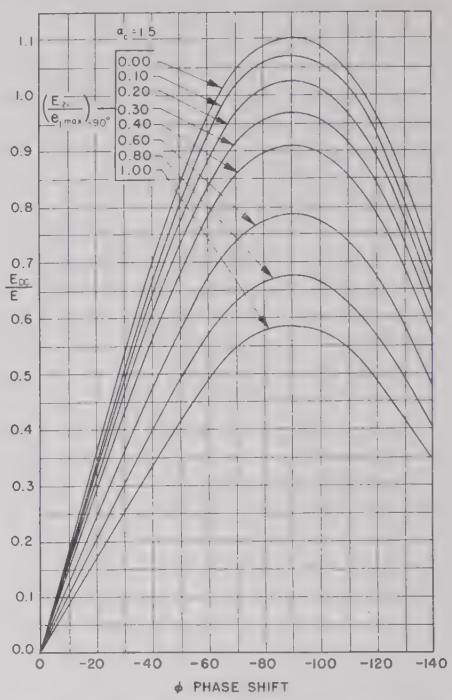


Fig. 8—General phase characteristics of the balanced discriminator with sinusoidal input when $\alpha_c=1.5$. To find $(E_{21}/e_{1\ max})$ use the one value $e_{1\ max}=2E$.

## Conclusions

The total phase characteristics of two basic types of phase-discriminators are given in a form which enables quick calculation of the proper performance curve. Only two assumptions are made; one, that the ripple across the load is negligibly small; and two, that each tube conducts when the others are nonconducting. The first assumption is easily justified, and the second introduces only a minute error in practical cases. It appears that, in both circuits, the sensitivity is increased by large $R_{bb}$, and small $R_1$ and tube resistance. However, the value of $R_1$ must be large enough in the balanced circuit to ensure the constancy of $E_{bb}$ by giving a large time constant $(R_s+R_T)C$. The slight increase in linearity, over only a part of the range, which is gained by adding $R_1$ is more than offset by the undesirable loss of sensitivity.

The balanced circuit seems to be less desirable than the simple one, but there is one important feature to consider. The output of the simple circuit is the difference between two large voltages. This gives inaccurate operation for small phase angles in a practical circuit where tubes and resistors are not perfectly matched. To its advantage, the balanced circuit output is the sum of two large voltages and this tends to reduce the effect of an error in either.

## Acknowledgment

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# Loading and Coupling Effects of Standing-Wave Detectors*

K. TOMIYASU†, MEMBER, IRE

*Summary*—**When measuring impedances on transmission lines, insensitive standing-wave detectors have the effect of yielding lower standing-wave ratios than the true values. Double-hump distribution curves are shown to be the result of very tight coupling of the detector. Detectors than can be represented by a susceptance component may indicate unsymmetrical distribution curves. Sensitive detectors used on transmission lines having low power levels can introduce tight coupling effects. Conditions are given for a loosely coupled detector.**

## Introduction

IMPEDANCES at ultra-high frequencies, and higher, are usually measured indirectly either from the shape of a standing-wave distribution or from the resonance-curve distribution[1] using a sensitive detector. The presence of a detector disturbs the electromagnetic field it measures and the pointer readings are subject to corrections. It is desirable to know how much a detector disturbs the field and how to eliminate or correct for the errors involved.

Altar, Marshall, and Hunter,[2] state that, for deep probe penetrations in waveguides, " . . . the appearance of more than one maximum per half-cycle . . . is clearly unaccounted for by the shunt-admittance theory. . . . " Dowker and Redheffer[3] also report unusual effects when deep probe penetrations are used. Since both investigators made use of voltage probes, the effects are somewhat obscured because greater coupling, and larger susceptance effects occur simultaneously. These effects can be separated by using a current probe.

In the literature an interesting discussion of detectors is found,[4] together with a partial treatment of their effects on a line having a matched generator. However, the important case of a loosely coupled generator and the unusual effects of tightly coupled detectors have not been considered heretofore.

## Equivalent Detector Admittance

A voltage detector that is tuned to resonance can be represented by a pure conductance, whereas if it is significantly detuned or has a large shunting capacitance, it can be represented by a pure susceptance.

The loading and coupling effects of standing-wave detectors depend upon the combination of three admittances: generator, detector, and load. When the generator is loosely coupled to the line, the effects of tightly coupled detectors are much more conspicuous than when the generator is matched. Usually detectors are tuned to resonance in order to obtain the maximum sensitivity, but occasionally detuned detectors are used—for instance, in broad-band applications. In order to analyze the most useful combinations of generator and detector admittances, the loosely coupled generator and tuned detector are considered in Part I, the matched generator and tuned detector in Part II, and the detector represented by a pure susceptance in Part III.

## I. Loosely Coupled Generator and Tuned Detector

The circuit under consideration is shown in Fig. 1. A

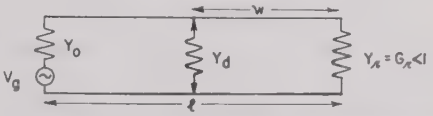


Fig. 1—Schematic circuit diagram of the transmission line with a detector in shunt.

loosely coupled generator would require the generator admittance, $y_0 \to 0$, and a tuned detector would mean that $y_d = g_d$.

### A. Apparent Standing-Wave Ratio

The relationship between the apparent and true VSWR (voltage-standing-wave-ratio) can be computed from the line equations. Referring to Fig. 1 and letting $y_d = 0$ for the moment, the voltage at $w$ is

$$V_w = V_g \frac{\cosh \gamma w + y_r \sinh \gamma w}{(1 + y_r/y_0) \cosh \gamma l + (y_r + 1/y_0) \sinh \gamma l}, \quad (1)$$

where

$V_g$ = generator voltage
$\gamma = \alpha + j\beta$, complex propagation constant
$w$ = distance from load
$l$ = total length of line
$y_0$ = normalized generator admittance
$y_r$ = normalized load admittance
$y_d$ = normalized detector admittance.

Without loss in generality, the terminating impedance can be specialized to a pure conductance having a normalized value less than unity since any phase angle may be added by a section of line. For an arbitrary gene-

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† Formerly, Cruft Laboratory, Harvard University, Cambridge, Mass.; now, Sperry Gyroscope Co., Great Neck, L. I., N. Y.

[1] D. D. King, "Impedance measurement on transmission lines," PROC. I.R.E., vol. 35, pp. 509–514; May, 1947.

[2] W. Altar, F. B. Marshall, and L. P. Hunter, "Probe error in standing-wave detectors," PROC. I.R.E., vol. 34, pp. 33P–45P; January, 1946.

[3] Y. N. Dowker and R. M. Redheffer, "An Investigation of RF Probes," Radiation Laboratory Report 483–14, NDRC Div. 14, OEMsr-262, February 6, 1946.

[4] C. G. Montgomery, "Technique of Microwave Measurements," vol. 11, chap. 8, Radiation Laboratory Series, McGraw-Hill Book Co., New York, N. Y., 1947.

rator admittance, a tuned detector ($y_d=g_d<1$), and a lossless line ($\alpha=0$) the apparent VSWR, which is less than the true VSWR, $1/g_r$, can be calculated by combining the apparent load admittance at the expected distribution extremes with the detector admittance. This yields

$$VSWR_a = \frac{1}{g_r}\left|\frac{y_0 + g_r + y_0 g_r g_d}{y_0 + g_r + g_d}\right|. \qquad (2)$$

For a loosely coupled generator, $y_0 \rightarrow 0$, and

$$VSWR_a = \frac{1}{g_r + g_d}. \qquad (3)$$

This is the ratio of the voltage at $\lambda/4$ from the voltage minimum to the voltage at the minimum. If the detector coupling is less than critical, this ratio is simply that of voltage maximum to voltage minimum. When the loading effect of the detector at a voltage minimum is not severe, $g_d \ll 1/g_r$, the true VSWR, $1/g_r$, and hence $g_d$, can be obtained from either the width of the resonance curve with the detector near the voltage minimum or the width of the distribution minimum.[1,5]

### B. Detector Deflection as a Function of Detector Coupling

Ideally, a detector must give maximum response from a given weak signal. Detectors of this type must be tuned to resonance and thus be tuned to the same frequency as the signal on the resonant transmission line. From low-frequency circuit theory,[6] if two resonant circuits are coupled more tightly than a critical value, the secondary current will decrease from a maximum. At the critical value, the reflected resistance is equal to the primary resistance.

Let us consider a resonant transmission line to be the primary and a resonant detector to be the secondary of two coupled circuits. The detector deflection, $D$, which is proportional to the secondary current, is given by:

$$|D| \propto \frac{k}{k^2 + k_c^2}, \qquad (4)$$

where

$k$ = coefficient of coupling,

$k_c = \dfrac{1}{\sqrt{Q_1 Q_2}}$, critical coupling.

Equation (4) is plotted in Fig. 2 and clearly shows the linear relationship of deflection to coupling when the latter is much less than critical. Such a curve can be obtained if the location of the standing-wave detector is fixed and the coupling varied.

[5] K. Tomiyasu, "Problems of Measurement on Two-Wire Lines with Application to Antenna Impedance," Cruft Laboratory Technical Report No. 48, Harvard University, June 15, 1948.

[6] Cruft Electronics Staff, "Electronic Circuits and Tubes," chap. 7, sec. 8, McGraw-Hill Book Co., New York, N. Y., 1947.

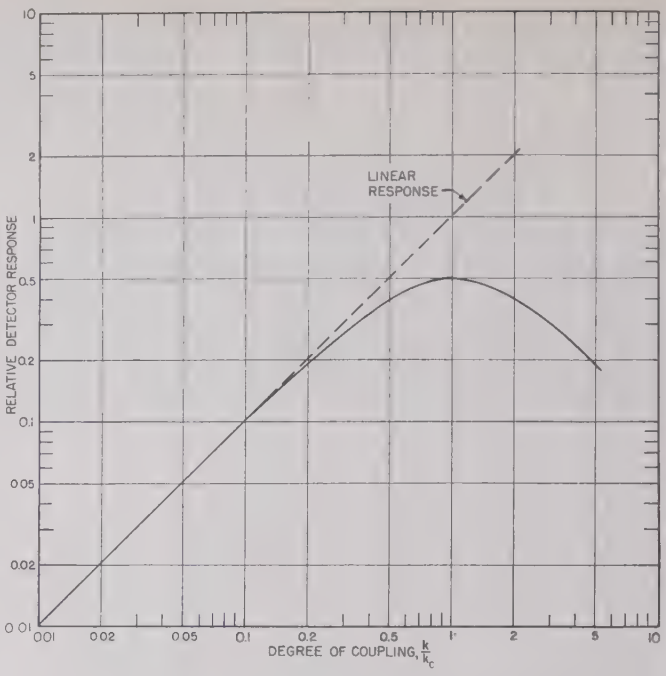


Fig. 2—For loose couplings, $k/k_c \leqq 0.1$, the detector response is linear. Maximum deflection is obtained at critical coupling.

### C. Distribution Curves as a Function of Detector Coupling

The distribution curves on a transmission line depend not only on the coupling of the detector but on the coupling of the generator as well. If the generator is loosely coupled to an unloaded line and the tuned detector is displaced longitudinally, the deflections obtained are exactly the same as the currents in the secondary of a conventional lumped-constant circuit whose coefficient of coupling is varied cosinusoidally. This can be shown readily by equating the power absorbed by the detector on the transmission line to the power absorbed by the secondary of the lumped-constant circuit. For a low-damped line, the effect is the same as varying cosinusoidally the coefficient of

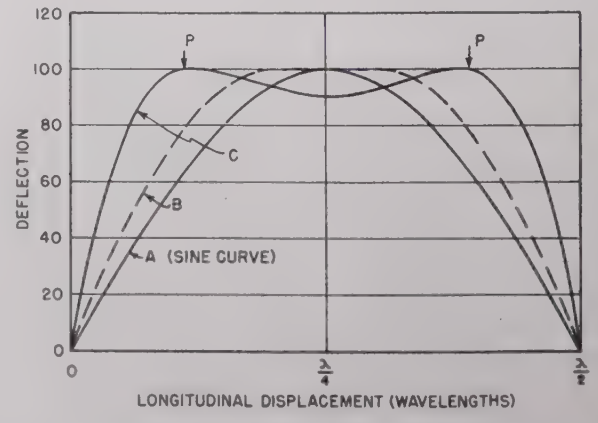


Fig. 3—Standing-wave distributions on an unloaded line for three detector couplings. The normalized curve $A$ is for loose coupling, curve $B$ for critical coupling, and curve $C$ for a coupling greater than critical.

coupling in the lumped-constant circuit in all regions not near minimum deflections.

For a sinusoidal variation in coupling on an unloaded line, a sinusoidal distribution will be found only if the detector is coupled far below critical at the distribution maximum. Such a distribution is shown as curve $A$ in Fig. 3. If the detector is tightly coupled, the maximum deflection will not occur at the expected position, but rather at two symmetrically located peaks, one on each side of the expected position. This is shown by curve $C$. It is quite apparent that if a detector is over-coupled at the normal distribution maximum, the deflection will be smaller at this location than at either of the side peaks $P$, where the coupling between the two circuits, line and detector, has been reduced to the critical value. In the transition, i.e., critical coupling, the distribution curve will assume a flat top as shown by curve $B$. Actually, if the plots are of observed deflections, curve $A$ would not reach the same maximum value as curve $B$ or curve $C$, since it is coupled less than critical. In the graph, curve $A$ has thus been normalized to the increased maximum value for clarity. All curves are symmetrical since the detector is tuned.

From ordinary transmission-line equations, the positions of distribution extremes for a tuned detector and a loosely coupled generator can be shown to satisfy the equation

$$CSg_r^2(g_r^2 + 2g_rg_d - 1) + CSg_d^2(C^2 + g_r^2S^2)^2 = 0 \quad (5)$$

where

$$C = \cos \beta w$$

$$S = \sin \beta w.$$

The slope of the distribution curve is zero when $\cos \beta w = 0$ and when $\sin \beta w = 0$. This is true for all values of $g_d$. However, when $g_d$ equals a critical value,

$$g_d \doteq g_r(1 - \tfrac{3}{2}g_r^2), \text{ (for small values of } g_r), \quad (6)$$

not only is the slope of the distribution curve equal to zero when $\cos \beta w = 1$, but the second space derivative as well. This means that the distribution curve becomes "flat-topped" at the expected maximum. Hence for critical coupling the effective shunting conductance of a tuned detector is approximately equal to the terminating conductance. This assumes a lossless line.

For couplings greater than critical, the locations of maximum deflections are obtained from the equation

$$\cos \beta w = \pm (1 - g_rg_d)\sqrt{g_r/g_d} \text{ (neglecting } g_r^2 \text{ compared to 1)} \quad (7)$$

and the distribution curve is characterized by a double hump.

If the detector admittance has a susceptance component as well, the distribution curves will become unsymmetrical within each half-wavelength. For couplings greater than critical, the higher peak will be indicated by the shift of the distribution maximum. (The shifts due to a susceptance detector are considered in Part III.)

### D. Resonance-Curve Width as a Function of Secondary Coupling

A further investigation of conventional lumped-constant circuits reveals some interesting results concerning the over-all damping of the coupled system. The over-all damping effect can be measured by the width of the resonance curve.[1] From the secondary current equation[7] the resonance-curve width $\Delta S$ is given by

$$\Delta S = \frac{\Delta\lambda_1}{\lambda_0} = \frac{1}{\sqrt{1 - Q_2(k_c^2 + k^2)}} - \frac{1}{\sqrt{1 + Q_2(k_c^2 + k^2)}}, \quad (8)$$

where $\Delta\lambda_1$ = change in primary resonance wavelength for the half-power points, and
$\lambda_0$ = operating wavelength.

Applying (8) to special cases, a loosely coupled secondary ($k^2 \ll k_c^2$) yields

$$\frac{\Delta\lambda_1}{\lambda_0} \doteq \frac{1}{Q_1}\left(1 + \frac{k^2}{k_c^2}\right) \doteq \frac{1}{Q_1} \equiv \Delta S_0$$

for 1 per cent maximum error, $Q_1 > 10$. (9)

For a critically coupled secondary ($k = k_c$) the resonance-curve width is

$$\Delta S = 2\Delta S_0. \quad (10)$$

An infinite half-power width is obtained for a coupling coefficient of:

$$k \doteq \frac{1}{\sqrt{Q_2}} \quad \text{for 1 per cent maximum error } Q_1 \geqq 100$$
$$= k_c\sqrt{Q_1}. \quad (11)$$

In Fig. 4 the resonance-curve width from (8) as a function of secondary coupling is plotted. For couplings much smaller than critical the resonance-curve width $\Delta S$ is a constant and the effect of the tuned detector is negligible.

### E. Condition for a Loosely Coupled Detector

For negligible effects a tuned detector must be loosely coupled to the line. If loose coupling is arbitrarily defined as

$$\frac{k}{k_c} \leqq 0.1, \quad (12)$$

this is equivalent to the following relationship:

$$g_d \leqq \frac{1}{98} g_r. \quad (13)$$

When loosely coupled, the apparent VSWR differs by less than one per cent from the true value and the deflections are proportional to the coupling.

[7] Equation (8.10), footnote reference 6.

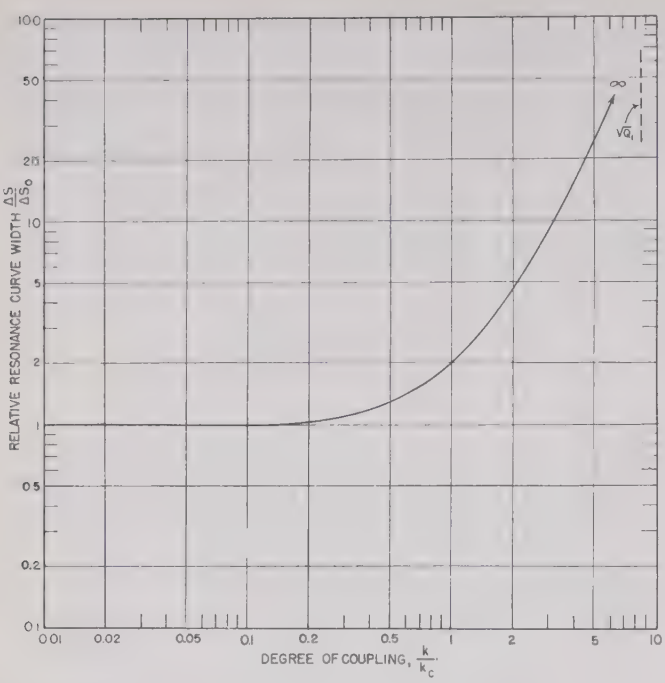


Fig. 4—Relative resonance-curve width of a low-damped line as a function of detector coupling. $\Delta S_0$ is the width when the detector is very loosely coupled.

Since the condition for loose coupling depends upon critical coupling, it also depends upon the primary $Q_1$. Increased dissipation in the primary decreases $Q_1$ and increases $k_c$. A larger $k_c$ reduces the possibility of over-coupled effects. This further implies that if over-coupled effects are not observed on an unloaded line, there certainly will not be any over-coupled effects when the line is terminated in a dissipative load.

## II. Matched Generator and Tuned Detector

When the generator is matched to the line ($y_0=1$) all readings and effects are independent of the distance between the generator and the detector. This means that resonance-curve widths cannot be measured.

### *A. Apparent VSWR*

For a matched generator and a tuned detector, the apparent VSWR from (2) is given by:

$$VSWR_a = \frac{1}{g_r}\,\frac{1+g_r+g_rg_d}{1+g_r+g_d}. \tag{14}$$

### *B. Distribution Curves as a Function of Dector Coupling*

For a matched generator and a tuned detector the zero slopes of the distribution curve occur only at cos $\beta w=0$ and sin $\beta w=0$. This means that double-hump curves cannot be found, and critical coupling of the detector does not exist. If the loading effect is significant, the distribution curves will be altered to yield the apparent VSWR given by (14). The distribution curves will be symmetrical.

### *C. Condition for a Loosely Coupled Detector*

For a line with a low-damped termination, the condition for loose coupling of the tuned detector is given by:

$$g_d < \frac{1+g_r}{99-100g_r} \doteq \frac{1}{99} \quad \text{for} \quad g_r^2 \ll 1. \tag{15}$$

The error in the apparent VSWR for this condition will be less than one per cent.

## III. Detector Represented by a Pure Susceptance

The most apparent effect of a susceptance detector regardless of the coupling of the generator is an unsymmetrical distribution curve. The analytical solutions for the effects of this detector are readily obtainable only when the generator is matched to the line.

### *A. Shift of the Distribution Extremes*

From conventional transmission-line equations, and assuming a lossless line, the distribution extremes are obtained by taking the space derivative of the absolute magnitude of the voltage at the detector and setting it equal to zero. The shifts $\delta$ of the voltage maximum and minimum are found to be:

$$\text{for } V_{\max}: \quad \frac{\delta_{\max}}{\lambda} \doteq \frac{-b_d}{2\pi(1+g_r)^2} \tag{16}$$

$$\text{for } V_{\min}: \quad \frac{\delta_{\min}}{\lambda} \doteq \frac{-b_dg_r^2}{2\pi(1+g_r)^2} \tag{17}$$

$$\text{subject to the condition } |b_d| \leqq \frac{(1+g_r)^2}{4g_r}.$$

A negative shift means that the observed location is closer to the load than the normal location. In order to clarify any ambiguity which may arise from the sign of the susceptance, $b \equiv -x/|z|^2$.

Both shifts are in the same direction and increase with increasing susceptance. Since $\delta_{\min}$ is less than $\delta_{\max}$ by a factor of $g_r^2$, $\delta_{\min}$ is indeed very small for small values of $g_r$.

From (16) the magnitude of the susceptance can be determined if the load conductance is known. A load of $g_r=0$ would be convenient for its determination. It can be readily shown that the combination of load and detector admittances at the distribution extremes does not yield a pure conductance.

### *B. Apparent VSWR*

Assuming that $b_d^2 \ll g_r^2 \ll 1$, the apparent VSWR is:

$$VSWR_a \doteq \frac{1}{g_r}\left[1-\frac{b_d^2g_r^2}{1+4g_r}\right]. \tag{18}$$

The fact that the susceptance appears squared signifies that the apparent VSWR will be identical for positive and negative susceptances of equal magnitude.

### C. Condition for a Loosely Coupled Detector

If the detector has a susceptance which is less than

$$|b_d| < \frac{\pi(1+g_r)^2}{180} \doteq \frac{\pi}{180}; \quad g_r \ll 1, \tag{19}$$

the error in the position of voltage maximum will be less than one degree.

If the susceptance is less than

$$b_d^2 < \frac{1+4g_r}{100g_r} \doteq \frac{1}{100g_r}; \quad g_r \ll 1, \tag{20}$$

the error in the apparent VSWR will be less than one per cent.

## Other Remarks

A study of the characteristics of coupled circuits reveals that for a coupling which is greater than critical, a maximum secondary current can be obtained that is the same as at critical coupling if both primary and secondary are simultaneously tuned to either longer or shorter wavelengths, with the oscillator frequency kept constant.[6] This is one test for determining the presence of over-coupled effects, and it has been verified in circuits having distributed constants.

An experimental method of determining if the detector is loosely coupled would be to change the coupling of the detector and compare the measurements. If loosely coupled, the measurements will be identical. The curves of Figs. 2, 3 and 4 have been verified qualitatively on a two-wire line operating at a frequency of 300 Mc.

The analysis thus far concerns the coupled detector and its effect; however, identical effects can be attributed to the generator which may be capacitively or inductively coupled to the line, for it, too, usually represents another coupled resonant circuit. The effect of a coupled generator is more easily corrected, provided, of course, the frequency and output voltage remain constant, since it is subtracted out in the resonance-curve width method and does not appear in the standing-wave-ratio method of measuring impedances.

## Conclusion

Impedances measured by the SWR method or by the resonance-curve-width method are a function of the detector coupling if the detector is not loosely coupled. Impedances measured from the position and width of a distribution minimum will not be in error if $g_d \ll 1/g_r$.

Simple crystal detectors with sensitive microammeters, which often exhibit loading and over-coupled effects, can be used without correcting for any errors if the power levels on the transmission line are high. Moreover, such detectors as bolometers, spectrum analyzers, and superheterodyne receivers, which have considerably higher sensitivities, may also exhibit loading and over-coupled effects when the prevailing power levels are extremely low.

It is hoped that by recognizing the errors introduced by tight coupling, proper adjustments can be made to eliminate their adverse effects.

## Acknowledgment

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# Analogue Studies of Losses in Reflex Oscillator Cavities*

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*Summary*—**An analysis is made which shows the method of applying the network analogue to the investigation of the effect of dielectric and wall losses on cavity-resonator behavior.**

**The $Q$ and shunt resistance of re-entrant cavities operating in the first- and second-order $TM_0$ type modes are investigated. The condition for a zero of shunt resistance is determined. Experimental results are discussed.**

## I. Introduction

PREVIOUS PAPERS[1,2] have described the design of network analogues for studying the electromagnetic field relationships in two-dimensional systems, and have indicated the wide variety of problems that may be handled. The present paper will be concerned with the application of such an analogue to the study of cavity-resonator losses in systems having axial symmetry. The analogue may represent either $TM_0$ or $TE_0$ type waves; however, the usual mode of coupling is such that the $TM_0$ mode is desired while

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‡ Stanford University, Stanford, Calif.; now on leave with the Office of Naval Research, Washington, D. C.

[1] K. Spangenberg, and G. Walters, "An electrical network for the study of electromagnetic fields," Technical Report No. 1, Electronics Research Laboratory, Stanford University, Contract N6-ORI-106, Task III, May, 1947.

[2] K. Spangenberg, G. Walters, and F. W. Schott, "Electrical network analyzers for the solution of electromagnetic field problems: Part I—Theory, design, and construction," PROC. I.R.E., vol. 37, pp. 724–729; July, 1949. "Part II—Operation," PROC. I.R.E., vol. 37, pp. 866–872; August, 1949.

the $TE_0$ mode often exists only as a parasitic oscillation, and in the perfectly symmetrical resonator cannot exist. Thus $TM_s$ modes only will be considered.

## II. Analysis

The literature[2,3] has shown in detail the analogy that exists for $TM_0$ modes, and certain of these results will be repeated to clarify the present development. In Fig. 1 is shown a section of the network. In terms of this figure the following notation is used:

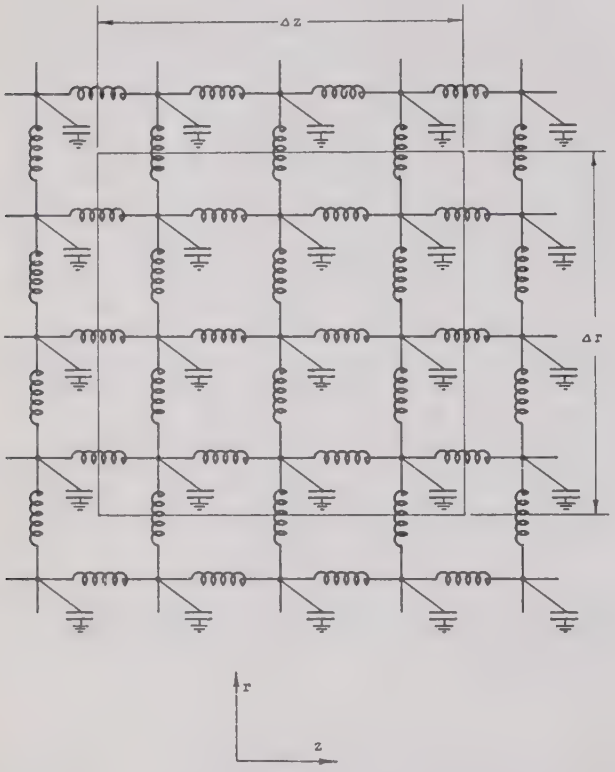


Fig. 1. Section of network.

$I_z$ = amperes per section, current per unit width flowing in the axial direction
$I_r$ = amperes per section, current per unit width flowing in the radial direction
$V$ = volts, voltage to the ground plane from any junction
$Z$ = ohms, coil impedance per unit square
$Y_\phi$ = mhos per section², admittance to the ground plane per unit area.

Upon comparing the field and network equations, the following tabulation is possible. The mks system is used and an harmonic time variation of the type $e^{j\omega t}$ assumed. Angular frequency is represented by $\omega$, the complex dielectric constant by $\epsilon(1-j\tan\theta)$, and permeability by $\mu$.

From Table I it is obvious that to represent the field properly $Y_\phi$ must decrease in inverse proportion to the radius and be capacitive, while $Z$ must be proportional to radius and largely inductive, having resistance in proportion to the loss factor $\tan\theta$.

TABLE I
Analogous Quantities for $TM_0$ Modes

| *Network* | *Field* |
|---|---|
| $V$ | $rH_\phi$ |
| $-I_r$ | $E_z$ |
| $I_z$ | $E_r$ |
| $Y_\phi$ | $\frac{j\omega\mu}{r}$ |
| $Z$ | $j\omega\epsilon(1-j\tan\theta)r$ |

### (A) *Cavity Shunt Resistance*

With the preceding basic relationships it is possible to proceed toward the objective of finding the analogue between cavity shunt resistance and $Q$, and the associated network quantities. First to be considered will be cavity shunt resistance.

Because $H_\phi$ does not vary with $\phi$, the wall loss is the same everywhere in the strip of infinitesimal width $\Delta w_c$ which encircles the axis of the cavity and is concentric with it. Hence, the total wall loss in the cavity may be written

$$P_c = 2\pi R_w \int_{\text{wall}} \frac{(r_c H_\phi)^2}{r_c}\, dw_c \tag{1}$$

where the subscript $c$ denotes quantities associated with the cavity.

To use the usual definition of shunt resistance, it is necessary to determine the integral of the electric field across the gap at the axis. Thus

$$V_{\text{gap}} = \int_{\text{gap}} E_z dz \tag{2}$$

which, in the mks system is, by Stoke's theorem

$$V_{\text{gap}} = j\mu\omega_c \int_{\text{area}} \frac{r_c H_\phi}{r_c}\, da_c \tag{3}$$

so that the expression for shunt resistance with which it is convenient to work is

$$R_{sh} = \frac{|V_{\text{gap}}|^2}{P_c} = \frac{\omega_c^2\mu^2\left[\int_{\text{area}} \frac{r_c H_\phi}{r_c}\, da_c\right]^2}{2\pi R_w \int_{\text{wall}} \frac{(r_c H_\phi)^2}{r_c}\, dw_c}. \tag{4}$$

Next, it is necessary to carry out an analogous procedure for the network. If the analogue of cavity gap voltage is first considered, it must be recalled that $E_z$ has $I_r$ as its network counterpart. Thus, while one forms (2) for the cavity, the analogue is

$$I_{\text{gap}} = \int_{\text{gap}} I_r dz. \tag{5}$$

[3] J. R. Whinnery, and S. Ramo, "A new approach to the solution of high-frequency field problems," Proc. I.R.E., vol. 32, pp. 284–288; May, 1944.

This latter integral can be seen to represent simply the total coil current flowing in the gap region in the network.

In order to proceed further, it is necessary to carry out a transformation somewhat similar to the one used previously. In (4) the numerator was transformed to an integral involving $H_\phi$ by the use of Stoke's theorem; for the network analogue the following may be done: Since for $TM_0$ modes the boundary conditions are imposed on the network by causing the network currents normal to the boundary to be zero, the current flowing in the gap is the total current entering in the $r$–$z$ plane of the network. Hence

$$I_{\text{gap}} = \int_{\text{gap}} I_r dz = -\int_{\text{area}} \text{div } I da_N \tag{6}$$

where the integration is to be performed over the area in the $r$–$z$ plane of the network. Upon considering the network equations, it is seen that

$$I_{\text{gap}} = \int_{\text{area}} V Y_\phi da_N. \tag{7}$$

In order to have the proper analogue for cavity wall loss it is necessary to investigate (1). This relation shows that the loss associated with each annular ring of width $\Delta w_c$ is proportional to $(r_c H_\phi)^2$ and inversely proportional to $r_c$. Since $r_c H_\phi$ has as its analogue network voltage $V$, it is simply necessary to connect at each junction lying along the network boundary a resistor, the value of which is proportional to the radius to the junction. If a conductance $1/R_s$ per unit width is connected at each junction along the network boundary, the total "wall" loss in the network is given by

$$P_N = \sum \frac{V^2}{R_s} \Delta w_N \cong \int_{\text{wall}} \frac{V^2}{R_s} dw_N. \tag{8}$$

It is then possible to write a relation corresponding to (4) which is the network equivalent to cavity shunt resistance. It is

$$G_N = \frac{\left[\int_{\text{gap}} I_r dz\right]^2}{P_N} = \frac{\left[\int_{\text{area}} V Y_\phi da_N\right]^2}{\int_{\text{wall}} \frac{V^2}{R_s} dw_N} \tag{9}$$

which may be considered as defining $G_N$, the network conductance. Introducing the radial variation of the quantities $Y_\phi$ and $R_s$ by writing

$$Y_\phi = Y_{\phi 1} \frac{1}{r_N} \tag{10}$$

$$R_s = R_{s1} r_N \tag{11}$$

where $Y_{\phi 1}$ and $R_{s1}$ are constants which express the value of the quantity at unit radius, and dividing (4) by (8), then

$$\frac{R_{\text{sh}}}{G_N} = \frac{\omega_c^2 \mu^2 \left[\int_{\text{area}} \frac{r_c H_\phi}{r_c} da_c\right]^2 \frac{1}{R_{s1}} \int_{\text{wall}} \frac{V^2}{r_N} dw_N}{Y_{\phi 1}^2 \left[\int_{\text{area}} \frac{V}{r_N} da_N\right]^2 2\pi R_w \int_{\text{wall}} \frac{(r_c H_\phi)^2}{r_c} dw_c}. \tag{12}$$

In the latter form, the integrals appearing in the numerator and denominator are very similar. In view of the analogue

$$V = k(r_c H_\phi) \tag{13}$$

where $k$ is some constant factor, and also

$$r_N = \beta r_c \tag{14}$$

where $\beta$ is the scaling factor for the network, or the number of sections of network per meter of actual cavity, thus

$$\frac{R_{\text{sh}}}{G_N} = \frac{\mu^2}{2\pi} \frac{\omega_c^2}{Y_{\phi 1}^2 \beta^2 R_w R_{s1}}. \tag{15}$$

Equation (15) is a general result which might be applied to any network of this type when representing $TM_0$ modes. The Stanford network has a characteristic velocity of $2.5 \times 10^6$ sections per second as compared to a velocity of $300 \times 10^6$ meters per second for free space, hence

$$\frac{\omega_c}{\omega_N} = 120\beta. \tag{16}$$

When this condition is introduced into (15) along with the relation that

$$|Y_{\phi 1}| = \omega_N C_1 = 800 \cdot 10^{-12} \omega_N, \tag{17}$$

the result is

$$\frac{R_{\text{sh}}}{G_N} = \frac{1.8\pi 10^9}{R_w R_{s1}}. \tag{18}$$

The loading level, i.e., the size of the wall-loading resistors in the network, is somewhat arbitrary but, as will be discussed later, a $R_{s1}$ of 100,000 ohms was found to be most suitable. In addition, it is true that for all materials

$$\frac{R_w}{\eta_1} = \pi \frac{\delta}{\lambda} \tag{19}$$

where $\delta$ is the depth of penetration as usually defined,[4] and $\eta_1$ is the characteristic impedance of free space (377 ohms in the mks system).

Thereby, a useful form of the result is obtained:

$$R_{\text{sh}} \frac{\delta}{\lambda} = \frac{150}{\pi} G_N. \tag{20}$$

As a matter of fact, this result is expected, since it is known that the quantity $R_{\text{sh}}(\delta/\lambda)$ is the same for all

[4] S. Ramo, and J. R. Whinnery, "Fields and Waves in Modern Radio," John Wiley and Sons, Inc., New York, N. Y., 1944.

geometrically similar resonators operating in the same oscillation mode.

*(B) Possibility of a Zero of Shunt Resistance*

From (4) it may be seen that shunt resistance is proportional to $[\int_{area} H_\phi \, da_c]^2$. For the lowest $TM_0$ oscillation mode $H_\phi$ is in time phase over the entire region and the above integral always has a nonzero value. For the second-order oscillation modes, however, $H_\phi$ changes sign over part of the region so that essentially

$$\int_{area} H_\phi da_c = \int_A |H_\phi| \, da_c - \int_B |H_\phi| \, da_c \qquad (21)$$

where regions $A$ and $B$ are separated by the nodal surface of $H_\phi$.

This indicates the possibility that the total integral, and hence the shunt resistance may be zero for the higher modes. A criterion may be established in this way: For the higher modes, there is always a surface (or line in the $r$–$z$ plane) passing through a point of zero electric field along which there is no tangential component of electric field. Such a surface may be called a nodal surface in a restricted sense only, for along it, the normal component of electric field is not zero. If a contour of integration be made to coincide with this "nodal" surface and the axis, it is apparent that the only contribution to $\int \overline{E} \cdot \overline{ds}$ along such a path will be along the axis. It may be shown that this integral must be greater than zero in general.

The magnitude of the electric field is given by

$$|E| = \frac{1}{\omega_c \epsilon r_c} \text{grad } (r_c H_\phi). \qquad (22)$$

Therefore, the "nodal" surface of electric field must lie between the zeros of $r_c H_\phi$. In all $TM_0$ modes $H_\phi$ (and $r_c H_\phi$) is zero along the axis. Thus, the first type of nodal surface to be encountered in moving out radially is one of electric field. Since

$$\oint \overline{E} \cdot \overline{ds} = j\mu\omega_c \int_{area} H_\phi da_c \qquad (23)$$

and inasmuch as $H_\phi$ is of the same sign over this area because of the integration path which has been chosen, the integral cannot be zero. Consequently, the shunt resistance cannot be zero in any such general case. There remains but one situation that will permit a zero of shunt resistance; *it exists when the nodal surface of $H_\phi$ passes through the gap*. A very simple example of such a case is the $TM_{011}$ mode in the elementary cylindrical resonator.

*(C) Cavity Q*

The work of the preceding section in the analysis of cavity shunt resistance points out the type of reasoning that must be pursued in the investigation of cavity $Q$.

The criterion for the wall loading has already been determined. Therefore, it is simply necessary to establish the analogue of cavity $Q$ in terms of network quantities and thus obtain the desired conversion factor.

The stored energy in the cavity is

$$W_c = \int_{vol} \mu H_\phi^2 dv_c \qquad (24)$$

since $H_\phi$ represents the rms value of the magnetic field. As before, an integration in the $\phi$ direction may be performed immediately because $TM_0$ waves are being considered. Thus, the stored energy is

$$W_c = 2\pi \int_{area} \mu H_\phi^2 r_c da_c \qquad (25)$$

and recalling (1) which expresses the wall loss, a result for cavity $Q$ is obtained in the form

$$Q_c = \frac{2\pi\mu\omega_c \int_{area} \frac{(r_c H_\phi)^2}{r_c} da_c}{2\pi R_w \int_{wall} \frac{(r_c H_\phi)^2}{r_c} dw_c}. \qquad (26)$$

This is to be compared with a corresponding ratio for the network. Here also the loss corresponding to the wall loss has been expressed. Rewriting (8)

$$P_N = \frac{1}{R_{s1}} \int_{wall} \frac{V^2}{r_N} dw_N. \qquad (27)$$

Hence, it is only necessary to determine the stored energy in the network. Because the time phase relationships are such that the junction voltage reaches its maximum everywhere at the same instant, the network stored energy is

$$W_N = \sum V^2 \Delta C \cong C_1 \int_{area} \frac{V^2}{r_N} da_N \qquad (28)$$

with $C_1$ referring, as before, to the capacity per unit area at unit radius.

The final expression for network $Q$ then becomes

$$Q_N = \frac{\omega_N C_1 \int_{area} \frac{V^2}{r_N} da_N}{\frac{1}{R_{s1}} \int_{wall} \frac{V^2}{r_N} dw_N} \qquad (29)$$

Taking the ratio of (26) to (29) and recalling (13), (14), (16), and (19), then

$$Q_c \frac{\delta}{\lambda} = \frac{1}{200\pi} Q_N. \qquad (30)$$

This result, as (20), is somewhat restricted but the same observation may be repeated: The quantities $R_{sh}(\delta/\lambda)$ and $Q_c(\delta/\lambda)$ are, for a given oscillation mode, functions of the geometry only.

*(D) Dielectric Losses*

The only losses previously considered were those associated with the finite conductivity of the resonator walls. However, when the resonator is used with

vacuum tube, the portion of the resonator containing the interaction gap must be evacuated; but it is generally not expedient to operate a tunable cavity entirely under a vacuum. Therefore, a glass seal is ordinarily placed around the gap region to permit the tunable portion of the cavity to operate in air. This dielectric material may occupy but a very small portion of the cavity volume and it may, in addition, have a loss factor of the order of 0.001, yet it may contribute very greatly to the total losses.

In order to represent the dielectric loss properly, it must be made to exist in the proper proportion relative to the wall loss. That is, once a factor has been decided upon for the wall loss, i.e., the amount of network wall loading, the same factor must be used for the dielectric loss. Thus

$$\left(\frac{P_{\text{wall}}}{P_{\text{dielectric}}}\right)_{\text{cavity}} = \left(\frac{P_{\text{wall}}}{P_{\text{dielectric}}}\right)_{\text{network}}. \tag{31}$$

From (30) it may be seen that with a wall loading represented by $R_{s1}=10^5$ ohms, the wall loss in the network is increased by a factor of $\lambda/200\pi\delta$. Consequently, the series resistance used to represent the dielectric loss, which from Table I is seen to be the product of tan $\theta$ by the corresponding coil reactance, must be given by

$$R_{d1} = \frac{\lambda\epsilon' \tan\theta\omega_N L_1}{200\pi\delta} = \frac{5\epsilon' \tan\theta}{\delta\beta} \tag{32}$$

where $R_d=(R_{d1})(r_N)$ and $R_{d1}$ represent the series resistance at unit radius. Thus (20) and (30) are not inviolated by dielectric loss. Rather, (32) tells how to represent the dielectric loss to maintain their validity.

## III. Method of Measurement

The theory developed in the previous section has shown that in order to determine the generalized cavity $Q$ and shunt resistance, measurements of network $Q$ and shunt conductance must be made. These measurements are quite simple in nature; however, to obtain a reasonably high degree of accuracy in making network measurements, certain precautions must be taken. Some of these have been discussed in footnote reference 2, but there are others pertinent to the type of observations made in this study.

When making observations of field configurations, the excitation source may be most conveniently connected to the network at a junction point through a large isolating resistance. The particular junction point used for this purpose is quite arbitrary, the only limitation being that the point chosen must not lie near a node of voltage. When the network is driven with this precaution it appears near resonance as a parallel $R$–$L$–$C$ circuit to the exciting source; this is desirable, for any harmonics which may be present tend to be attenuated. The magnitude of the isolating resistance is also somewhat arbitrary. From the standpoint of obtaining a large amount of excitation, this resistance should be as small as possible; but the impedance to ground, as viewed at the network junction when looking toward the source, should be large if the field configuration is not to be affected. A suitable compromise is readily found.

### (A) *The Measurement of Network Q*

In a network having a high ratio of stored energy to loss per cycle, the field distribution at resonance is independent of the manner or point of excitation. A suitably designed network meets this requirement and the $Q$ therefore may be observed at any point. If the network is viewed between a junction point and ground, it appears as a parallel-resonant circuit and measurements may be made in the appropriate manner. Again, if the network is opened at any point, it appears series-resonant between the resulting pair of terminals, and the techniques for measuring the $Q$ of a series circuit may be used.

Because of the method used to observe cavity field configurations and because of possible harmonics in the voltage source, the network $Q$ is most readily determined by the former of the two methods which is illustrated in Fig. 2. If the isolating resistor is large, e.g., ten times the equivalent network resistance $R_p$, the current to the network will remain constant when the frequency of the exciting source is varied slightly. The network $Q$ may then be observed by noting the fractional detuning necessary to reduce the response at point $A$ by a specified amount. In certain cases where the network resonance being studied is far removed in frequency from an adjacent resonance, larger amounts of detuning may be used to advantage for obtaining increased accuracy.

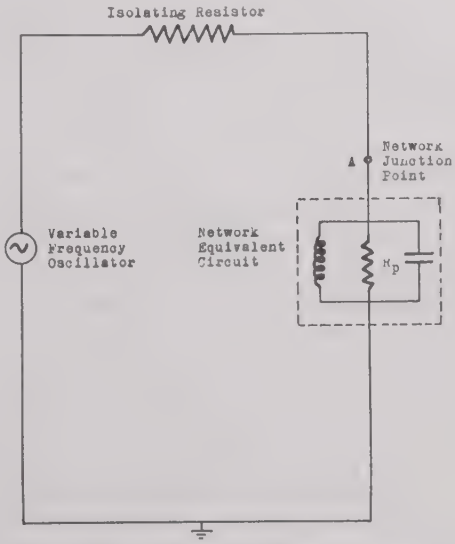


Fig. 2—Basic circuit for $Q$ measurements.

The network $Q$ which is desired is that associated with the losses which are represented by loading the network, as previously noted in the theoretical discussion. Unfortunately, there are always superimposed on these losses the effects of the coil resistance. These coil losses

are in no instance negligible and must be accounted for properly.

It has been stated that the amount of wall loading is arbitrary. This is true as far as the analysis was carried, but it was always assumed that the field configuration was that associated with walls having infinite conductivity. Such a situation prevails to a high degree in an actual cavity and must, therefore, be realized also in the network. From the standpoint of simplicity, it would be desirable to use a network loading sufficiently large so that any other loss would be small in comparison. This is not feasible. Various experiments were tried, and it was found that the greatest wall loading that could be tolerated was of such a magnitude that this contribution to the loss was less in all cases than that arising from the finite coil resistance.

There is consequently no choice but that all $Q$ determinations must consist of two measurements. The first must be made with no wall loading and a value $Q_0$ determined. The second may then be made with the proper wall loading and a new value $Q_1$ found. The desired value is then given by:

$$\frac{1}{Q_N} = \frac{1}{Q_1} - \frac{1}{Q_0}. \tag{33}$$

For the particular wall loading used, i.e., $R_{s1} = 100{,}000$ ohms, the generalized cavity $Q$ is then found immediately by (30).

### (B) *The Measurement of Network Conductance*

By definition, the network conductance $G_N$ is the ratio of the square of the total network current flowing in the gap to the power dissipated. In view of the method used for other measurements, it is often desirable to excite the system at a junction point and evaluate $G_N$ from this definition.

If the magnitude of the isolating resistor of Fig. 2 is accurately known, the power to the network may be determined by measuring the voltage at the oscillator and at the point of excitation. The network appears resistive at resonance, hence the power is simply the product of the voltage at the excitation point and the current. The current is that flowing in the isolating resistor and is evaluated in terms of the voltage drop across the resistor.

The total network gap current may be calculated by measuring the frequency and the voltages across the radial coils extending from the axis to the first row in the region corresponding to the interaction gap. The number of radial coils forming the gap depends, of course, on the relative gap width, and the gap current is the sum of these individual coil currents.

The network conductance is determined in this manner as a ratio of (gap-current)$^2$ to power. Since both current and power are evaluated from voltage measurements, the accuracy of these results is independent of any linear voltmeter error.

Direct measurements of $G_N$ may also be made. If the network is opened along the axis, it will appear series-resonant and measurements may be made accordingly. One type of direct measurement that may be made is with a Wheatstone bridge arrangement as shown in Fig. 3. The bridge may be balanced only when the network

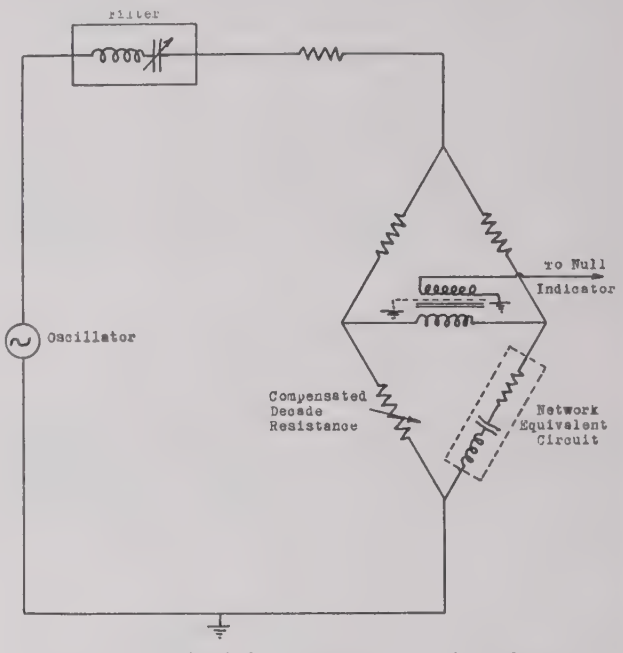


Fig. 3—Bridge circuit for measuring network conductance.

appears resistive, hence the excitation frequency and the variable arm of the bridge must be adjusted simultaneously. Fortunately, the impedance level is quite low, usually less than 100 ohms in each arm, which permits reasonably accurate measurements to be made without taking extreme care to eliminate stray capacitive effects. It is necessary that the arms of the bridge consist of resistors that do not vary with frequency. This requirement is easily met in the fixed arms but in the variable arm it was found necessary to use a compensated decade resistor.

In these measurements, as well as in the $Q$ measurements, the losses associated with the coils must be considered. If a determination be made with no added resistors, the effective series-resonant circuit will have a resistance which may be termed $1/G_{N0}$. When the terminating resistors are then connected to simulate the wall losses, a larger series resistance $1/G_{N1}$ will be observed. The desired resistance is the difference between these values, hence

$$\frac{1}{G_N} = \frac{1}{G_{N1}} - \frac{1}{G_{N0}}. \tag{34}$$

## IV. Verification of the Theory

### (A) *The Shunt Resistance and Q Relationships*

The theory which has been developed may be readily verified by measurements upon simple cylindrical

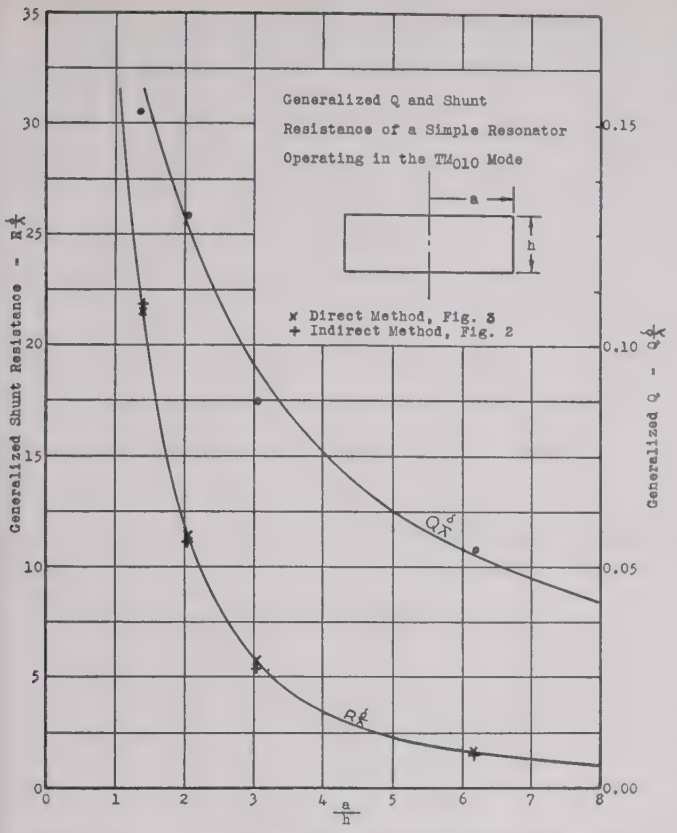


Fig. 4—Comparison of network data with theory, $TM_{010}$ mode.

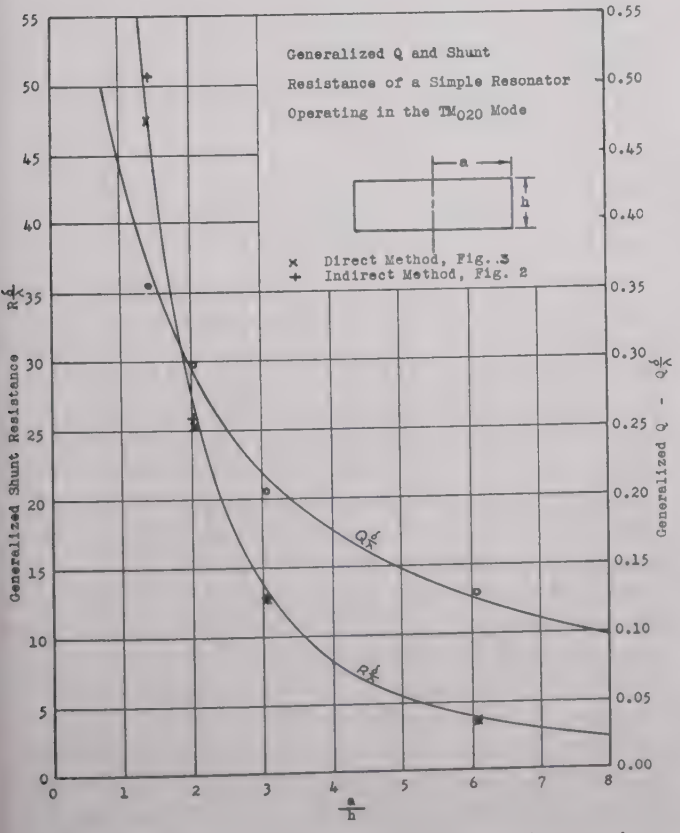


Fig. 5—Comparison of network data with theory, $TM_{020}$ mode.

resonators. If a can-shaped structure of radius $a$ and height $h$ be considered, it is readily shown that the shunt resistance and $Q$ of $TM_{0n0}$ modes are expressed by

$$R_{sh}\frac{\delta}{\lambda}=\frac{60}{\pi J_1^2(k_c a)\,\frac{a}{h}\left(\frac{a}{h}+1\right)} \tag{35}$$

and

$$Q_c\frac{\delta}{\lambda}=\frac{k_c a}{2\pi\left(\frac{a}{h}+1\right)}. \tag{36}$$

Measurements have been made by the methods which have been described, and the results are presented in Figs. 4 and 5 which follow. Here are shown the theoretical relations which should exist for $TM_{010}$ and $TM_{020}$ modes, and the observed data.

It was felt desirable to make a further check on the theory with a type of structure more closely approximating those utilized in actual resonators. A simple reentrant cavity was selected and the net-point method used to solve the finite difference form of Maxwell's equations. The solution by the net-point method involves a reiteration or relaxation process starting from an assumed field configuration, and the labor involved is, therefore, relatively little when the initial assumption is nearly correct. But the network, if properly representing the fields, automatically satisfies these very difference equations; hence, it is convenient to take as an initial set of values, those from the network. The net-point calculations were, of course, carried out for an idealized lossless system rather than for a network with coils having a finite $Q$; yet the method produced no substantial change in the net-point data. This is shown in Table II, which compares the results of computations based on the refined data with actual measurements.

TABLE II

Comparison of Theory and Measurements

| | *Calculated* | | *Measured* | |
|---|---|---|---|---|
| | $R$ | $Q$ | $R$ | $Q$ |
| First-Order Mode | 5.20 | 0.074 | 5.05* 5.35† | 0.078 |
| Second-Order Modes a. Low Frequency | 0.06 | 0.154 | very small | 0.15 |
| b. High Frequency | 1.71 | 0.213 | 1.77* 1.6† | 0.22 |

* Measured directly, using bridge method.
† Measured by exciting network as parallel resonant circuit.

The Stanford network was constructed with a "fine" section in which the spacing is one-half that in the major portion of the network; thus additional experiments

could also be performed to determine the effect of network spacing. Re-entrant cavities were represented first on a section of the analyzer having the larger spacing; the experiments were then repeated using the "fine" section in the vicinity of the gap region (where the fields tend to have the most rapid spatial variations). It was found that there was no appreciable difference in either the field distribution or the measured cavity parameters as long as the nominal wavelength was represented by roughly fifteen network sections or more.

As a result of these and other observations it is believed that the error associated with the measurements may be maintained generally within five per cent. The $Q$ measurements and the shunt resistance measurements made by exciting the networks as a parallel-resonant circuit can be repeated within approximately five per cent of the calculated value. The bridge method for measuring shunt resistance produces values that may be consistently repeated within two per cent, but the results for the lowest-order mode are invariably low. The reason for this is not completely understood.

### (B) *The Condition for a Zero of Shunt Resistance*

The verification of the criterion which has been established for the existence of a zero of shunt resistance is possible by a simple example. It has been stated that the shunt resistance may be zero when the node of $H_\phi$ lies in the interaction gap; thus it is expected that if a tunable coaxial-type cavity operating in a second-order $TM_0$ mode be investigated, this situation may be found.

In Fig. 6 is shown a particular re-entrant cavity for which this effect has been observed. If for large values of $l$ the cavity operates in the mode usually termed the "three-quarter wave mode," the field configuration in the coaxial portion of the resonator resembles that of a $TEM$ mode and the resonant frequency is relatively sensitive to the length $l$. When, on the other hand, the plunger is moved flush with the inner conductor, i.e., when $l=s$, the field is that of the $TM_{020}$ mode in which the lines of electric field are purely axial in direction. Here the resonant frequency is relatively insensitive to the plunger position as may be seen from the normalized tuning curve, and as is expected from the perturbation theory of Slater.[5] In passing from the first condition to the second, the nodal surface of $H_\phi$ was carefully observed, and it was found that the shunt resistance became extremely small as the node approached the gap. It was of interest to note that the rate of change of the nodal position with respect to the length of the cavity was very great in this vicinity.

It was also of interest to note the behavior of the other second-order mode in this region. This other mode has characteristics indicated by the dotted curves in

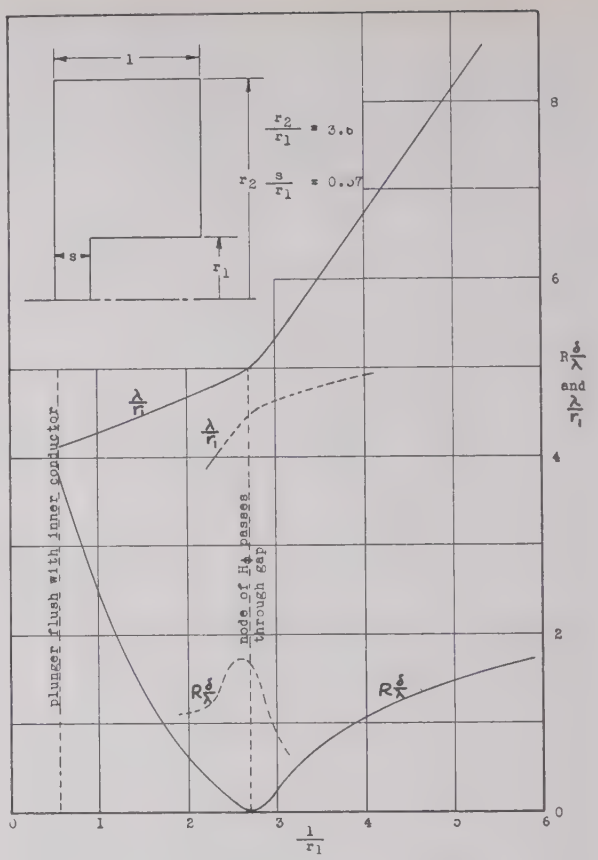


Fig. 6—Behavior of shunt resistance of the low-frequency second-order $TM_0$ mode.

Fig. 6. These show that although the desired mode might not be capable of excitation for $l/r \simeq 2.6$, there is for the same geometry a nearby resonance for which the shunt resistance is not zero.

## V. Methods of Avoiding a Zero of Shunt Resistance

Before pursuing this consideration in detail, it is well to consider the possible oscillation modes that may be excited in a cavity when operating as an integral part of a reflex oscillator. The lowest mode, which has a zero of $H_\phi$ along the axis of the resonator only, is seldom used in tunable reflex oscillators because of the constructional limitations associated with the small sizes involved; this is perhaps unfortunate, not only because of the situation mentioned above, but also because the lowest mode is nearly always far removed in frequency from any others. The most commonly used mode is one of the second-order $TM_0$ modes, so designated because there are two nodal surfaces of $H_\phi$, one of which is along the axis (and is strictly only a line) and another of which is removed from the axis. Now it must be emphasized that usually only one of the second-order modes is desirable but that there are, in general, two possible second-order mode types, which may or may not be widely separated in frequency. As an illustration, there is shown in Fig.

[5] J. C. Slater, "Microwave electronics," *Rev. Mod. Phys.*, vol. 18, pp. 444–512; October, 1946.

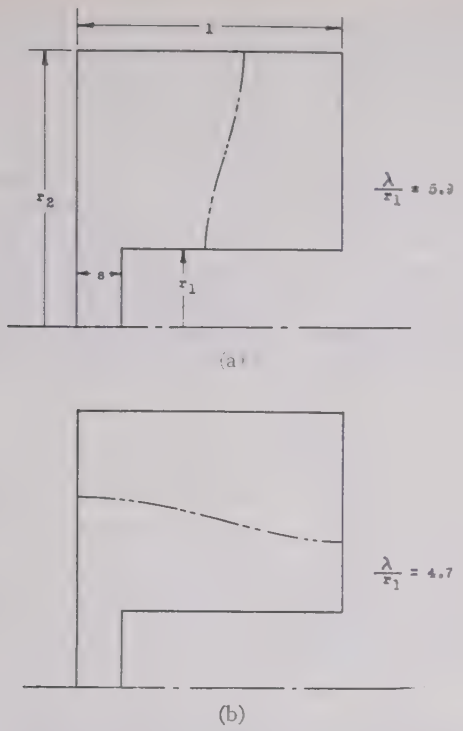


Fig. 7—Position of the nodal surface of $H_\phi$ for the two second-order modes in a simple re-entrant cavity.

a simple re-entrant cavity and the position of the nodal surfaces of $H_\phi$ for the two possible second-order modes. For this particular case, the frequencies differ by roughly 25 per cent. In addition, the shunt resistance is approximately the same for both field configurations so that the other factors, such as the characteristics of the electron beam passing through the gap would determine which of the modes would be excited.

It is now possible to investigate what may happen if a resonator is to be operated over a frequency range by tuning the cavity by means of an adjustable plunger. If the length of the resonator is large compared with the other dimensions, as is usually the case at the low frequency end of the tuning range, the desired field configuration will be of the type shown in Fig. 7(a). Also, for cavities of large axial length the second-order mode having the lowest frequency will be the one for which the direction of the lines of electrical field (which coincide with contours of constant $rH_\phi$) are predominately radial. This is necessary if there is to be a reasonable change in resonant frequency with change in plunger position; the frequency of a configuration of the type of Fig. 7(b) is highly insensitive to the cavity length.

In a practical case then, if the cavity is in its low-frequency position the nodal surface of $H_\phi$ will lie in an almost radial plane. As the frequency is increased by moving the plunger toward the gap region, the nodal surface of $H_\phi$ will also move in that direction. This nodal surface will become distorted, however, as the frequency is further increased, until the field configuration has become that of the $TM_{020}$ mode when the plunger is flush with the inner conductor. This is a general characteristic of simple re-entrant resonators, namely, that the nodal surface of $H_\phi$ shifts from a radial position to an axial position as the cavity length is decreased.

But there are two ways in which the nodal surface can progress. In Fig. 7(a) it may appear that the bottom of the nodal surface, or that portion of the node adjacent to the inner conductor, would move more rapidly away from the plunger face than the portion adjacent to the outer conductor. This is so. In fact, as this node changes its orientation as described above, the lower end will pass through the interaction gap as shown in Fig. 8(a). If excited suitably, this cavity could tune

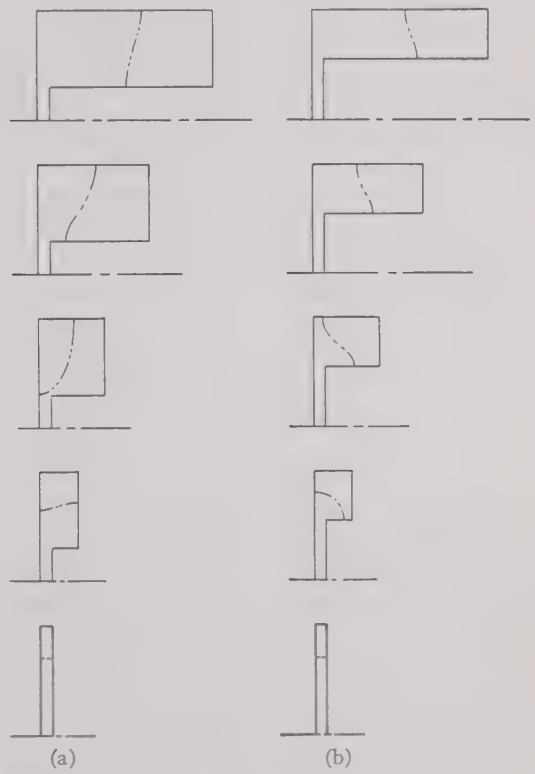


Fig. 8—Progression of the node of $H$ in two similar cavities.

smoothly over this range with the field behaving in the manner indicated, but *not if the cavity were excited in the normal manner*. The shunt resistance would become zero as the node of $H_\phi$ passed through the gap, and the cavity, if excited by an electron beam, would cease to oscillate in the desired mode. In practice, the shunt resistance would decrease as the node approached the gap, and when it became too low the cavity would cease to oscillate or jump to another mode.

Fortunately, this limitation on continuous tuning does not now seem to be of great importance, although it may become a factor to be considered if attempts are made to extend the tuning range of cavity resonators. Usually the nodal surface of $H_\phi$ does not pass through the gap until the plunger is very close to the gap, corresponding to a frequency above the high-frequency limit.

There is, however, a simple method which may be used to avoid this situation. If, as the plunger is moved toward the gap, the node of $H_\phi$ progresses in such a way that it does not pass through the gap, the shunt resistance cannot become zero. Thus in Fig. 8(b) is shown a slightly different geometry for which this second-order $TM_0$ mode always presents a reasonable shunt resistance.

Studies of actual reflex klystrons have revealed that, in at least those cases investigated, the geometry is such that the behavior is of the type of Fig. 8(b) and, therefore, this problem is avoided. As an example, there are shown in Fig. 9 the characteristics of the SD835

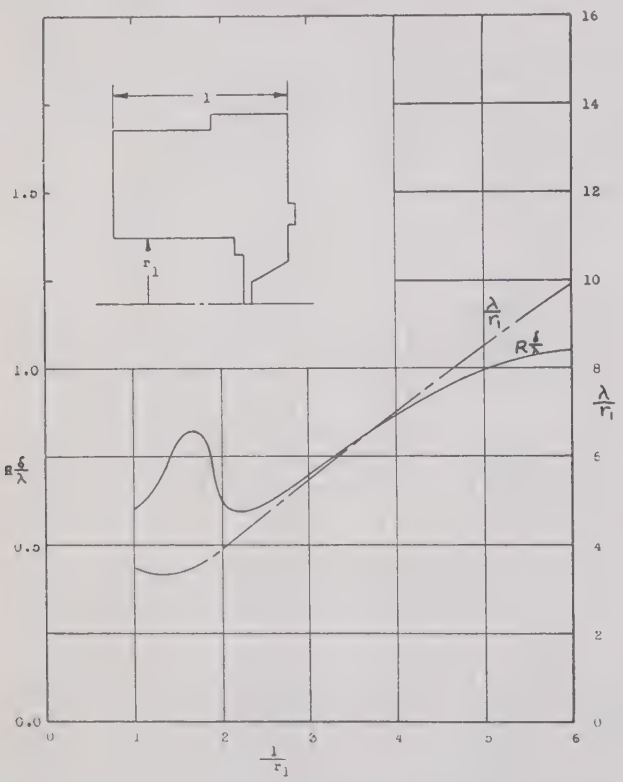


Fig. 9—Shunt resistance and tuning curve of the SD835 type cavity (without dielectric).

cavity type as the cavity length is varied. The generalized shunt resistance presented in this graph represents the effect of wall loss only and is, therefore, higher than the actual value, which is affected by dielectric loss.

In order to obtain general information regarding the possibility of a zero of shunt resistance, a systematic study of cavities of the type of Fig. 7 was made. The objective was to find a relation between the parameters $r_2/r_1$ and $s/r_1$ such that, as the cavity is tuned on the desired mode, the node of $H_\phi$ will not pass through the interaction gap. As a result it has been observed that the desired nodal progression exists when $(r_2/r_1)<2.2$ and is substantially independent of $s/r_1$ for practical structures in which $(s/r_1)<1$.

A completely general study of this type becomes extremely lengthy if a cavity with a large number of geometric variables is to be considered. In spite of this, however, a somewhat more complex cavity of the type shown in Fig. 10 has been investigated over a limited

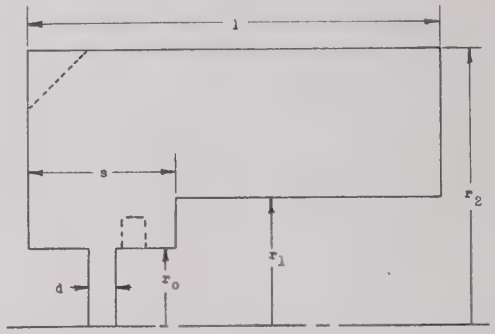


Fig. 10—A cavity with means for eliminating a zero of shunt resistance.

range. The only significant observation is that the effect of the step associated with $(r_1/r_0)>1$ is to permit utilization of $(r_2/r_1)>/2.2$ without encountering an undesirable type of nodal progression.

Of perhaps more importance is the determination of slight alterations that may be made to improve the behavior. Numerous methods were tried and it was found that either of the two methods shown by the dotted lines in Fig. 10 tended to eliminate a zero of shunt resistance.

## VI. Conclusion

The network analyzer is very valuable for investigating any particular cavity and provides an answer in a short time. It would be desirable, for the benefit of those not having analyzers available, to present in reports such as these a large amount of generalized data, so that any cavity might be designed by interpolation among such data. Unfortunately, the number of variables is so great that such a study is hardly feasible. As data are amassed, however, certain trends may be noticed which will be helpful to designers of cavity resonators. Furthermore, it is feasible to investigate the effect of the variation of dimensions about certain mean configurations.

# Beam-Loading Effects in Small Reflex Klystrons*

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*Summary*—**Beam-loading effects in small reflex klystrons have been measured experimentally by the use of electronic tuning data. They are found to be far greater than predicted by published analyses and to vary more or less linearly with total oscillator load, a variation not previously predicted.**

**An analysis of beam-loading effects produced by secondary electrons ejected into the intergrid space by the main electron stream is found to predict large loading and linear variation with load, and to allow the possibility of negative beam loading.**

## I. Preliminary Consideration

SIMPLE THEORIES of the reflex klystron[1,2] usually neglect the power lost from the resonator fields in the process of changing the velocities of the electrons during their initial transit. When this is included in a more thorough analysis,[3] it is found that the calculated effect of this power loss is equivalent to a constant conductance across the tube grids which is, in most cases, completely negligible compared with the conductance embodying the effects of resonator losses and other loads. Although the beam-loading phenomena in a typical small reflex klystron are calculated by Pierce and Shepherd to be "small and probably less important than various errors in the theory," when measurements are made the beam loading conductances are found to be comparable in size to the resonator conductances, and not at all negligible. Furthermore, the beam loading does not remain constant as the loading of the resonator is varied. Apparently other phenomena than those considered cause loading effects which overshadow the loading described by these analyses.

Abraham has found[4] that beam loading effects in a single transit resonator with mesh grids are much greater than predicted by simple theory. By comparing these results with nongridded apertures, he has established that this is due to the presence of secondary electrons emitted from the grids.

Measurements of beam loading in small reflex klystrons indicate an even greater disagreement with predicted behavior than for the single transit resonator. This is thought to be due to the fact that, whereas in the single transit resonator the secondary electrons are produced at a relatively constant rate, in the reflex tube the bunched electrons of the returning beam strike the grid after passing through the intergrid space and produce a shower of secondary electrons more or less simultaneously. This "bunch" of secondaries traveling back across the grid space might be expected to have considerable effect on the tube characteristics.

Secondary electrons produced by the going and returning primary electron stream may, in turn, produce other secondaries. These are generally unimportant because of their fewness, except in the case of much higher rf voltages than are encountered in the low-power tubes under consideration, when the multipactor action described by Abraham may cause very heavy loading.

This paper contains an account of the methods and results of making measurements of beam loading and, as an Appendix, an analysis which attempts to explain observed results in terms of loading by secondary electrons ejected into the intergrid space by the main electron stream.

## II. Measurements of Beam-Loading $Q$

The experimental method of measuring beam-loading $Q$ is one of measuring separately the "cold" $Q_L$ of the tube and cavity (with the accelerating voltage off but with the cathode hot) and the operating $Q_l$, and computing the beam loading from the assumption

$$\frac{1}{Q_b} = \frac{1}{Q_l} - \frac{1}{Q_L}. \tag{1}$$

The cold $Q$ measurement is by now too standard an operation to mustify elaboration here.[5,6] The basic equation for the determination of the operating $Q$ is easily derived from the familiar equivalent circuit for a reflex klystron and resonator.[1] The requirement for oscillation is that the sum of the electronic and resonator admittances be zero; hence the tangents of the phase angles of the admittances must be equal. Thus

$$\tan 2\pi(n + \tfrac{3}{4} - f\tau) = Q_l\left(\frac{f}{f_0} - \frac{f_0}{f}\right), \tag{2}$$

where $\tau$ is the repeller space transit time. Differentiating with respect to the repeller voltage and evaluating for $f\tau = n + \frac{3}{4}$, $f = f_0$, we have upon rearranging

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† University of Florida, Gainesville, Fla.

‡ Microwave Laboratory, Stanford University, Stanford Calif.

[1] E. L. Ginzton and A. E. Harrison, "Reflex klystron oscillators," PROC. I.R.E., vol. 34, pp. 97P–113P; March, 1946.

[2] D. R. Hamilton, J. K. Knipp, and J. B. H. Kuper, "Klystrons and Microwave Triodes," McGraw-Hill Book Co., Inc., New York, N. Y., pp. 254, 311–351; 1948.

[3] J. R. Pierce and W. G. Shepherd, "Reflex oscillators," *Bell Sys. Tech. Jour.*, vol. 26, Appendix 8, pp. 663–672; July, 1947.

[4] W. Abraham, "Loading of resonant cavities by electron beams," *Phys. Rev.*, vol. 72, p. 741; October 15, 1947.

[5] J. C. Slater, "Operation and testing of reflex oscillators," MIT Radiation Laboratory Report No. 742.

[6] C. G. Montgomery, "Technique of Microwave Measurements," McGraw-Hill Book Co., Inc., New York, N. Y., pp. 333–342, 1947.

$$Q_l = \pi f_0^2 \left| \frac{\left|\frac{d\tau}{dV_r}\right|}{\frac{df}{dV_r}} \right|_{f\tau = n+3/4} - \pi(n + \tfrac{3}{4}). \qquad (3)$$

In order to obtain $d\tau/dV_r$ it is assumed that $f\tau = n + \frac{3}{4}$ when $df/dV_r$ is a minimum. If measurements are taken on several modes at different frequencies a curve of $\tau$

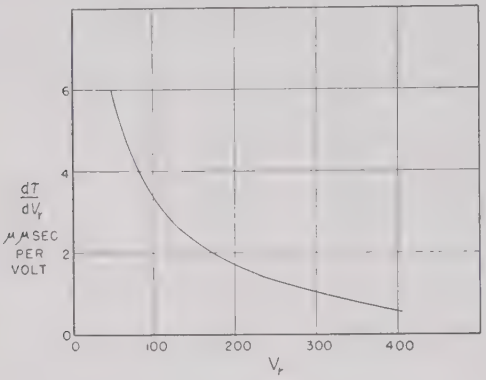


Fig. 1—2K28 repeller characteristic. Anode voltage, 300 volts.

versus $V_r$ (Fig. 1) may be plotted which permits accurate determination of $d\tau/dV_r$.

Thus (3) provides a means of determining the operating $Q_l$ from a measurement of the electronic tuning, $df/dV_r$. The second term in (3) is usually negligible.

The electronic tuning is conveniently measured by frequency modulating the klystron by superimposing a small sine or square wave on the repeller voltage and observing the resulting frequency spectrum when the output is beat down to a suitable frequency range. This may be done on a selective receiver for the square-wave modulation or with a spectrum analyzer type of circuit for the sine wave modulation. In the first case, the separation of the two output frequencies is measured; in the second, it is more convenient to measure the modulation coefficient of the frequency modulated output by varying the amplitude of the modulating voltage until the carrier first goes through zero.[7]

The experimental procedure may be facilitated by a method which requires but one cold $Q$ measurement for a series of beam-loading measurements. The klystron and its resonator are coupled to a standing-wave detector through a coupling loop and short coaxial line which are left unaltered throughout the series of measurements. The cold $Q_0$ measurement is made by feeding power from a signal generator through the standing-wave detector to the resonator. In the process of this measurement a reference point $x_0$ on the standing-wave detector will be found such that the admittance of the resonator and connecting line at this point will vary with frequency near resonance in the same manner as the admittance of an equivalent parallel resonant circuit.[8] This reference point will be the position of a voltage minimum when the frequency is the original resonant frequency of the cavity, the cavity being detuned. At resonance the reference point is the position of a voltage minimum if the cavity is undercoupled, or a voltage maximum if it is overcoupled.

In making operating $Q_l$ measurements the signal generator is replaced by an impedance transformer and load. The transformer is always adjusted so that either a voltage maximum or minimum appears at $x_0$ when the klystron is supplying power. In this case, neglecting the reciprocal of the voltage standing wave ratio (VSWR) when the cavity is far off resonance, it is easily shown that the resonator $Q_0$ is related to the $Q_l$ of the load by

$$\frac{Q_l}{Q_0} = \frac{\rho}{\sigma_0}. \qquad (4)$$

Here $\rho$ is the reciprocal of the VSWR for a voltage minimum at $x_0$ or the VSWR for a voltage maximum at $x_0$. The symbol $\sigma_0$ denotes the reciprocal of the VSWR at resonance for the undercoupled case or the VSWR at resonance for the overcoupled case when power is fed into the cavity. Thus

$$\frac{1}{Q_L} = \frac{1}{Q_0}\left(1 + \frac{\sigma_0}{\rho}\right), \qquad (5)$$

which permits the determination of the loading on the

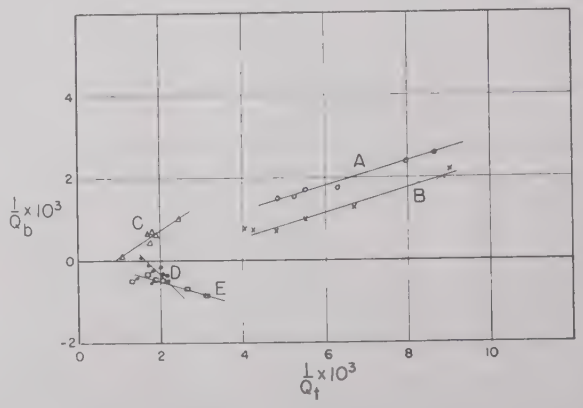


Fig. 2—Measured beam-loading of 2K28.

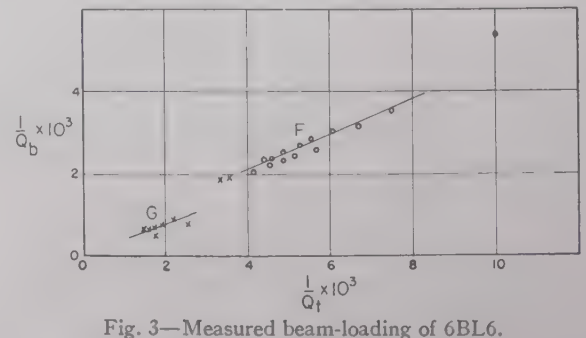


Fig. 3—Measured beam-loading of 6BL6.

[7] F. E. Terman, "Radio Engineers' Handbook," McGraw-Hill Book Co., Inc., New York, N. Y., p. 578; 1943.

[8] J. C. Slater, "Microwave electronics," *Rev. Mod. Phys.* vol. 18, pp. 441–512; October, 1946.

cavity for a series of loads with only one $Q_0$ measurement.

## III. Experimental Results

Results of beam-loading measurements are shown in Figs. 2 and 3 and interpreted in Table I. The resonators

TABLE I
Interpretation of Data in Figs. 2 and 3

| Data set | Tube | Manufacturer | Freq. (Mc) | Transit time (cycles) | Estimated $C'(\mu\mu f)$ |
|---|---|---|---|---|---|
| A | 2K28 | Raytheon | 3240 | $2\frac{3}{4}$ | 1.0 |
| B | " | " | 3240 | $3\frac{3}{4}$ | 1.0 |
| C | " | " | 3440 | $2\frac{3}{4}$ | 3.5 |
| D | " | " | 3455 | $2\frac{3}{4}$ | 3.5 |
| E | " | " | 3455 | $3\frac{3}{4}$ | 3.5 |
| F | 6BL6 | Sylvania | 3245 | $2\frac{3}{4}$ | 0.8 |
| G | " | " | 4095 | $2\frac{3}{4}$ | 4.0 |

used for runs A, B and F were simple cylinders fitting around the grid contacting rings. The remainder of the runs were taken in resonators which were closed sections of rectangular waveguides with the tube centrally located.

The beam-loading effects depend upon the rf voltage, and hence upon the net conductance at the tube grids. While the conductance is not easily measured directly, the product $Q_tG_t$ is a function of resonator configuration which may be estimated by various analytical and experimental methods. This product is conveniently expressed as an equivalent capacitance $C'$ defined by $\omega C' = Q_tG_t$. For a given resonator $G_t$ is proportional to $1/Q_t$.

In appraising the accuracy of these measurements it should be remembered that the beam-loading is obtained as the difference between two reciprocal $Q$'s which are both difficult to determine accurately, and which may be large compared with their difference. Probably the most serious uncontrollable error is due to the heating of the grids when the tube is operating, since this causes the resonator $Q_0$ to differ slightly for the two measurements.

## IV. Conclusions

Analysis of beam loading due to primary electrons alone predicts a small effect, independent of the external circuit. The analysis of Appendix I, including secondary electron effects, predicts a linear dependence of beam loading with the conductance appearing across the tube grids, such as appears in the experimental results of Figs. 2 and 3. Certain of the parameters appearing in the beam loading expression cannot be measured directly, so a quantitative comparison of theory with experiment is difficult. However, inserting what seem to be reasonable values of parameters in the results of this analysis, it would appear that the center of the "bunch" of secondary electrons emitted from the first grid would, in crossing the gap, encounter fields which were, on the average, decelerating and plots of $1/Q_b$ versus $1/Q_t$ should have a negative slope. The experimental data shows most often a positive slope.

Experiment indicates that beam loading in tubes with grids is far from the negligible quantity it is often assumed to be. For cases of heavy external loading, the beam loading conductance may exceed the conductance due to resonator losses. One result of this is to completely invalidate methods of measuring beam loading which assume it independent of rf voltage level. These measurements definitely indicate that beam loading effects which are hard to calculate, and hence usually neglected, may be far more important than minor second-order corrections to reflex klystron theory which are included because they are calculable.

## Acknowledgment

The authors wish to express their appreciation for the valuable suggestions and criticisms offered by Karl Spangenberg of the electrical engineering department and Marvin Chodorow of the physics department, of Stanford University.

## Appendix I—Calculation of Secondary-Electron Beam-Loading Effects

The general scheme of analysis of secondary-electron beam loading is to compute the energy taken from or given to the rf field by one secondary electron which is emitted at an arbitrary phase angle $\omega t = \phi$ of the rf field

$$E = \frac{V_1}{d} \sin \omega t$$

between the grids at an average value of emission velocity. Assuming a constant proportionality factor between numbers of secondaries and primaries, this energy can be summed over an rf cycle to yield a net energy gain or loss, from which a conductance can be computed. Here the number of primary beam electrons striking the grids at any phase angle is obtained from klystron bunching theory.

For primary energies of less than a thousand electron volts experimental studies[9] of secondary emission indicate that the majority of secondaries emitted from the grids will have normal components of emission velocities which are only a few per cent of the primary electron velocity. A very few, perhaps a few per cent, may be expected to have velocities approximately equal to the primary velocity. Since a small change in velocity corresponds to an energy change approximately proportional to the velocity, the maximum energy contribution per electron will come from these "direct reflection" secondary electrons. However their number is so small that the major effect must be attributed to the more abundant low velocity secondaries.

If the normal component of initial velocity with which an electron leaves a grid be $u_0$, the velocity perpendicular to the grid at time $t$ is given by

$$v_t = u_0 + \int_{\phi/\omega}^{t} \frac{e}{m} E dt = u_0 + \frac{V_1 e}{dm\omega} (\cos \phi - \cos \omega t). \quad (6)$$

[9] J. H. O. Harries, "Secondary electron radiation," *Electronics*, vol. 17, pp. 100–108, 180; September, 1944.

Substitution of representative values in this expression demonstrates that except for the very lowest velocity secondaries this velocity is always positive, i.e., always directed toward the opposite grid. This is important because in a moment we wish to average the kinetic energy per electron over a full cycle of transit time, and the averaging is more complicated if the electrons reverse their direction of travel at any time.

Now if $t_1$ is the time at which the electron reaches the opposite grid, we may set the distance at time $t_1$,

$$s_{t_1} = \int_{\phi/\omega}^{t_1} v_t dt = \frac{V_1 e}{\omega^2 dm}\left[\left(\cos\phi + \frac{\omega d m u_0}{V_1 e}\right)\omega t_1 + \sin\phi - \phi\cos\phi - \frac{u_0\phi\omega dm}{V_1 e} - \sin\omega t_1\right], \quad (7)$$

equal to $d$, the grid spacing.

Considering this distance equation, we see (Fig. 4)

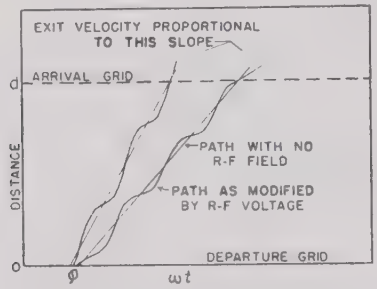


Fig. 4—Distance-time plot of secondary electrons in radio-frequency field between two grids.

that the path of an electron is represented in the distance-time plane by a straight line (first terms) of a slope dependent on $u_0$ with a superimposed sinusoidal variation (last term). For representative values of grid spacing and initial velocity, the electron will take at least several cycles to travel the intergrid distance. (This is reasonable, remembering that the time of transit for the primary electrons in these tubes is in the neighborhood of a third of a cycle.)

We consider for a moment two secondary electrons produced at the same phase angle with slightly different initial velocities following the trajectories shown in Fig. 4. The exit velocity and energy depend on the slope of this path at the point where the electron leaves the grid space, that is, at the distance $d$. We note that the exit velocity changes considerably for a small change in initial velocity. Put somewhat differently, over a small range of values of initial velocity (i.e., average slope of path) the transit time $(\omega t - \phi)$ will vary by a half-cycle and the change in electron velocity due to its experiences in the grid space will go from maximum increase to maximum decrease. Thus, averaging the energy change over a cycle of transit time is equivalent to averaging over a range of emission velocities. Extending this argument, we may obtain a mean value of energy averaged over the complete range of emission velocities by averaging the energy over one cycle of transit time and substituting an average value $\bar{u}_0$ of emission velocity.

The mean energy change per electron, as a function of $\phi$, thus obtained is

$$\Delta W(\phi) = \frac{1}{2\pi}\int_0^{2\pi}\frac{m}{2}(v^2 - u_0^2)d(\omega t) = \frac{V_1^2 e^2}{2\omega^2 d^2 m}\left[\frac{2\omega d}{V_1}\sqrt{\frac{2U_0 m}{e}}\cos\phi + \cos^2\phi + \frac{1}{2}\right], \quad (8)$$

where we have introduced $U_0$, the mean emission energy in electron volts, i.e., $\frac{1}{2} m\bar{u}_0^2 = eU_0$. In this integration we have treated the mean velocity $\bar{u}_0$ as a constant, having shown that $\omega t$ is a rapidly varying function of $u_0$.

The product of this energy change with the rate (expressed as a function of $\phi$) at which secondary electrons are produced, averaged over a complete cycle of $\phi$, yields the power loss (or gain) due to secondary electron beam loading. It may be noted that if the rate of secondary production is constant, i.e., there is no bunching and the primary electrons are evenly distributed throughout the cycle, the quantity in the brackets averages to unity. We take the number of secondaries produced per second to be $\eta = (kI_T/e)$ where $k$ is the ratio of total secondaries produced to number of primary electrons incident on the grids (perhaps 0.1).

The expression for the sum of the going (dc) and returning (bunched) currents from ordinary bunching theory is taken to be

$$I_T = 2I_0\left[1 + \sum_{n=1}^{\infty} J_n(nx)\cos n(\phi - \phi_1)\right], \quad (9)$$

where $x$ is the bunching parameter and $\phi_1$ is the phase angle of the rf voltage when the center of the returning bunch strikes the grid nearest the cathode. The total power loss is then

$$P_s = \frac{1}{2\pi}\int_0^{2\pi}\eta\Delta W(\phi)d\phi = \frac{keI_0V_1^2}{\omega^2 d^2 m}\left[1 + \frac{\omega d}{V_1}\sqrt{\frac{2U_0 m}{e}}J_1(x)\cos\phi_1 + \frac{J_2(2x)}{4}\cos 2\phi_1\right] \quad (10)$$

with higher-order terms in the summation integrating to zero because of the orthogonality of the trigonometric functions. With typical values, the last term in the brackets is negligible compared with the first two, and will be dropped.

We have now an expression for total power loss or gain resulting from the low-velocity secondaries. A secondary electron loading conductance $G_s$ is defined by $G_s = (2P_s/V_1^2)$ whence the total beam loading conductance $G_b = G_p + G_s$ becomes

$$\frac{G_b}{G_0} = \frac{G_p}{G_0} + \frac{2ekV_0}{\omega^2 d^2 m}\left[1 + \frac{\omega d}{V_1}\sqrt{\frac{2U_0 m}{e}}J_1(x)\cos\phi_1\right] \quad (11)$$

where $G_0 = I_0/V_0$ and $G_p$ is the equivalent conductance due to primary beam loading.

This expression still contains the quantities $x$ and $V_1$ for which it is extremely difficult to obtain good theoretical or measured values. However, we note that in operation we shall be interested in the value of beam loading at the center of a mode, under which conditions

$$\frac{|Y_e|}{G_0} = 2\pi N \frac{J_1(x)}{x} = \frac{G_t}{G_0} \tag{12}$$

where $G_t$ is the conductance seen across the tube gap, which may be taken as essentially the conductance due to the resonator and load losses when beam loading effects are small.

Combining (11) and (12) and noting that $1/Q_t = G_t/\omega C'$,

$$\frac{1}{Q_b} = \frac{1}{\omega C'}\left[G_p + \frac{2ekV_0G_0}{\omega^2 d^2 m}\right] + \frac{k}{\beta d\omega}\sqrt{\frac{2U_0 e}{m}}\,\frac{1}{Q_t}\cos\phi_1. \tag{13}$$

It should be remarked that $Q_b$ is implicit in $Q_t$ by the relation (1). Although (13) could be simply solved explicitly for $1/Q_b$, the form given indidates clearly the dependence on the total $Q_t$ as measured.

Equation (13) includes all the beam loading effects except those due to the "direct reflection" secondaries whose relative number is so small that they are found to contribute a minor portion of the total loading.

In order to obtain an idea of the relative importance of the various terms, we substitute some representative values for small external cavity klystrons into (13) and obtain

$$\frac{1}{Q_b} \approx 10^{-4} + \frac{10^{-2}}{Q_t}\cos\phi_1.$$

Examining voltage-current relations in the reflex klystron we find that at the center of a mode the bunch of electrons returning from the repeller space passes through the center of the grid space at a time when the field is maximum decelerating, i.e., $V_1 \sin \omega t$ is maximum, $\omega t = \pi/2$. We should expect, then, that the proper value to use for $\phi_1$ would be $\pi/2$ plus $\delta/2$ (assuming negligible emission time of the secondary electrons). For the tube under consideration, this is in the neighborhood of 150 degrees, so that the cosine is nearly unity and negative.

## Appendix II—Glossary of Symbols

$C'$ = equivalent capacitance representing tube grids
$d$ = grid spacing
$e$ = charge of an electron
$E$ = electric field
$f$ = frequency
$f_0$ = resonant frequency of cavity resonator
$G_b$ = beam loading conductance
$G_0$ = direct-current conductance equal to $I_0/V_0$
$G_p$ = conductance due to bunching of electron beam
$I_0$ = direct-current beam current
$I_T$ = total current
$J_n(x)$ = $n$th order Bessel function of the first kind
$k$ = ratio of number of secondary to primary electrons
$m$ = mass of an electron
$n$ = transit time mode number
$N$ = repeller space transit time in cycles equal to $f\tau$
$Q$ = circuit factor defined as the ratio of energy stored in the resonator fields to the energy loss per radian
$Q_b$ = $Q$ due to beam loading losses
$Q_t$ = $Q$ due to external load
$Q_L$ = $Q$ due to resonator losses and load
$Q_0$ = $Q$ due to resonator losses
$Q_t$ = $Q$ due to resonator losses, load, and beam loading
$t$ = time
$u_0$ = secondary electron initial velocity
$v$ = velocity
$U_0$ = secondary electron initial energy
$V_0$ = cathode-anode direct-current voltage
$V_r$ = repeller-cathode direct-current voltage
$V_1$ = peak radio-frequency voltage across grids
$x$ = bunching parameter equal to $\pi N\beta V_1/V_0$
$x_0$ = reference plane defined as the position of a voltage minimum with cavity detuned
$Y_e$ = electronic admittance
$\beta$ = gap modulation coefficient
$\delta$ = gap transit angle in radians
$\eta$ = number of secondary electrons produced per second
$\rho$ = reciprocal of voltage standing-wave ratio for voltage minimum at reference plane, voltage standing-wave ratio for voltage maximum at reference plane
$\sigma_0$ = reciprocal of voltage standing-wave ratio at resonance for undercoupled cavity, voltage standing-wave ratio at resonance for overcoupled cavity
$\tau$ = repeller space transit time
$\phi$ = phase angle of radio-frequency grid voltage
$\omega$ = angular frequency equal to $2\pi f$.

# Fluctuation Phenomena Arising in the Quantum Interaction of Electrons with High-Frequency Fields*

D. K. C. MacDONALD† AND R. KOMPFNER†

*Summary*—**On the basis of a quantum-mechanical analysis by Smith[1] of the interaction of an electron beam with an oscillating resonant cavity, the fluctuations in energy flow in the beam have been analyzed. The expressions for the classical and quantal cases are compared and it is concluded that, under extreme limiting conditions of operation, a just perceptible difference might be observed.**

## I. Introduction

RECENTLY Smith[1] has analyzed theoretically the energy exchange between a beam of electrons and a resonant cavity excited with electromagnetic energy. He deduces, quantum mechanically, that energy is always exchanged in units $h\nu$, where $\nu$ is the frequency of excitation, and has shown on this basis how the transition to a "classical" process occurs when the excitation energy is large compared with one quantum. On the other hand, for energies small compared with one quantum, many electrons will pass without suffering any energy change whatsoever, and thus the behavior in certain respects will differ considerably from that under classical conditions. In particular, the energy fluctuations in the electron beam will differ in the two cases and these we have essayed to analyze in this paper, assuming the validity of Smith's theory.

At conventional radio frequencies (say $10^6$–$10^8$ cps), a quantum of energy is so small that any difference on a classical or quantal basis must certainly be unobservable. At a wavelength of one centimeter, however ($\nu = 3 \times 10^{10}$ cps) the quantum corresponds to a potential

$$V_q = \frac{h\nu}{e} = 1.23 \times 10^{-4} \text{ volts} \qquad (1)$$

and this potential is of the same order of magnitude as the least perceptible signal voltage at the input of microwave receivers. It is, therefore, of interest to examine in principle the influence of the quantum hypothesis on the operation of microwave amplifying tubes and the sensitivity of such microwave receivers.

With electron streams originating at cathodes having temperatures $T_c$ around 1,000°K. as used at present, it is to be expected à priori that such quantum effects will be unobservable since in this case

$$h\nu \ll kT_c. \qquad (2)$$

Since, however, in principle a practically monoenergetic beam of electrons can be produced, it appears still worth while to investigate the question quantitatively.

## II. Analysis

Let us then consider the phenomenon of an electron beam traversing a resonant cavity at a place where there is an electric field parallel to the direction of motion of the electrons. Let us further assume that the electrons cross the cavity in a small fraction of a cycle, so that—in the classical case—the voltage increment given to the electron is equal to the instantaneous value of the electric field times the distance the electron is traveling in the field. Smith considers also a case of long transit time, but for our purpose it will be sufficient to treat the passage of an electron across the resonant cavity, and to assume with him, the act of energy interchange as instantaneous. In this case, an electron traversing the field at time $t$ will then classically acquire a voltage increment

$$V_t = V \sin \omega t \qquad (3)$$

where

$$\omega = 2\pi\nu$$

and $V$ is the peak voltage across the cavity. Thus the voltage increment is a smoothly varying function of time and any increment between zero and $\pm V$ is possible on this view.

In the quantum case, however, it appears from Smith's detailed analysis that energy will be interchanged only in units of

$$h\nu = eV_q \qquad (4)$$

that is to say, only voltage increments of integral multiples of $V_q$ are possible.[2] Smith has given general expressions for the probability of such interchange as a function of time, and has shown that the total energy exchange when averaged over a long time is equal to that in the classical case, and also that the voltage increments for large values of $V$ approach those of the classical case.

The expression for the probability that $N$ quanta be absorbed by an electron is

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† Clarendon Laboratory, Oxford, England.

[1] L. P. Smith, "Quantum effects in the interaction of electrons with high frequency fields and the transition to classical theory," *Phys. Rev.*, vol. 69, pp. 195–210; March, 1946.

[2] It is perhaps worth while to mention that the assumption is made here that energy is only exchanged with the electrons in the beam, and only with one of them at one time. In any practical resonant cavity, energy will also be dissipated as heat due to currents flowing in the walls.

It can be shown that conditions should be realizable where the possibility of quanta being shared in either of these ways can be excluded.

$$P_N = e^{-p\sin\omega t}\cdot\frac{(p\sin\omega t)^N}{N!}; \quad (0 \leqq \omega t \leqq \pi)$$
$$= 0; \quad (\pi < \omega t < 2\pi). \tag{5}$$

The probability that $N$ quanta be emitted by an electron is

$$P_N = e^{p\sin\omega t}\cdot\frac{(-p\sin\omega t)^N}{N!}; \quad (\pi \leqq \omega t \leqq 2\pi)$$
$$= 0; \quad (0 < \omega t < \pi) \tag{6}$$

the ratio of the peak voltage to the "quantum" voltage, $P = V/V_q$

$$\left(V_q = \frac{h\nu}{e}\right).$$

We are chiefly interested in the case where $p \ll 1$, where it is seen that energy is exchanged practically only in single quanta and the probability for absorbing one quantum becomes simply

$$P_1 = p\sin\omega t; \quad (0 \leqq \omega t \leqq \pi)$$
$$= 0; \quad (\pi < \omega t < 2\pi) \tag{7}$$

and for emitting one quantum

$$P_1 = -p\sin\omega t; \quad (\pi \leqq \omega t \leqq 2\pi)$$
$$= 0; \quad (0 < \omega t < \pi). \tag{8}$$

Thus the most probable phase for an electron to absorb one quantum is around $\pi/2$ and to emit around $3\pi/2$.

Fig. 1(a) has been drawn with this in mind, indicating however that, in actual fact, the phase of absorption or emission will fluctuate in a rather random fashion. Fig. 1(b) shows the idealized classical case for the purpose of comparison, and the assumption has been made, arbitrarily, that the rf peak voltage $V$ is $1/10\,V_q$. These figures bring out clearly the essential difference in the energy exchange process on the two views.

As mentioned above, the mean energy flow in both cases is the same; *the fluctuations in energy flow*, however, will clearly differ and this is the problem to be considered, since it is the fluctuation, or "noise" that will determine the limiting sensitivity of devices involving energy interchange between electron streams and electromagnetic fields.

The total fluctuation will arise from a number of sources:

(a) fluctuations in the rate of arrival of electrons ("shot effect") at the cavity.

(b) fluctuations in the energy content of electrons (thermal velocities of emission) arriving at the cavity. We propose to call this "chromatic noise."

(c) fluctiations in the amount of energy transferred. We propose to call this effect "transfer noise."

The first type of fluctuation is familiar; the second is less well known but is clearly of importance in problems of this type. The third contribution may arise in two different ways; in the classical case, if there were no fluctuation in the rate of arrival of electrons there would be no fluctuation in the rate of energy transfer. Since, however, the rate of arrival of electrons always fluctuates to some extent, this will result in a fluctuation of energy transfer. Clearly, the amount of energy fluctuation introduced in this case will be a function of the degree of smoothness (quantitatively defined by the symbol $\Gamma^2$) of the incident beam.

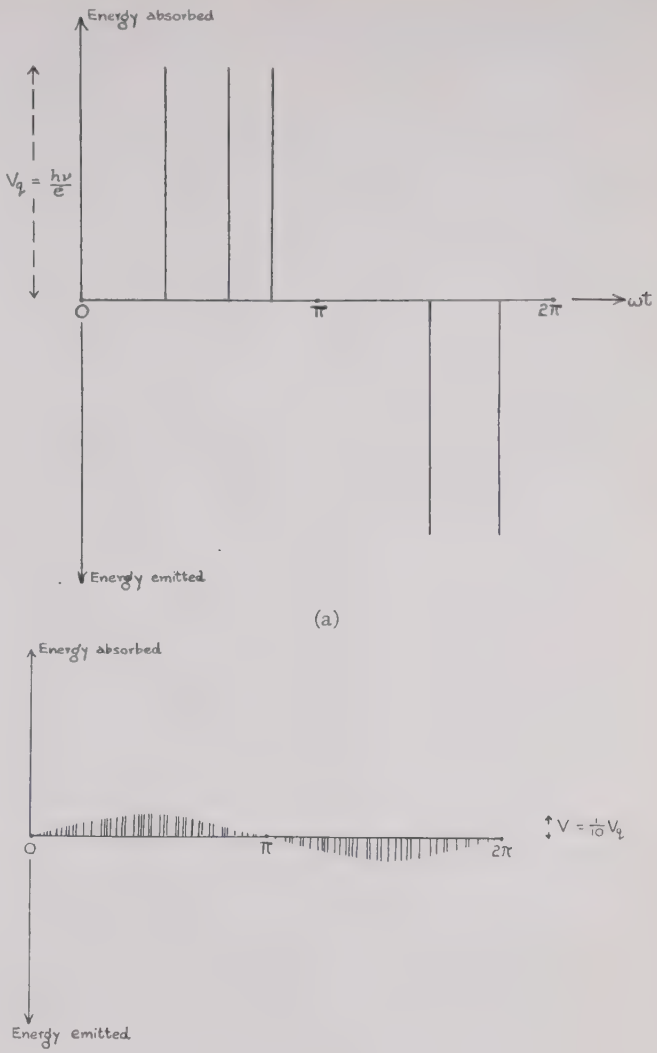



Fig. 1—The energy flow; (a) the quantum case, and (b) the classical case.

On the other hand, in the extreme quantum case, where the individual probability of transfer of energy $h\nu$ to a single electron is small, the fluctuation in energy transfer will, therefore, be essentially random irrespective of the degree of smoothness of the electron beam.

It will be assumed in the following analysis that all types of fluctuations are uncorrelated and simply add.[3] Hence the total fluctuation will be the sum of the three types of fluctuation. Detailed analysis yields the fol-

[3] In a conventional thermionic tube, the degree of space-charge smoothing is correlated with the energy spectrum; i.e., $\Gamma^2$ is a function of temperature—nonetheless, the electrons leaving the potential minimum have still essentially full chromatic noise. In any event, in the general case, one can readily visualize a beam exhibiting no shot fluctuatuations which possesses full chromatic noise and, on the other hand, a monochromatic beam with full shot effect.

lowing result for the complete energy transfer spectrum:

(*i*) *Classical case*

$$\overline{(W)^2} = \underbrace{\frac{N^2e^2V^2}{2}\cdot\delta(\nu-\nu_0)}_{\text{(signal)}} + \underbrace{2N^3e^4\Gamma^2Z^2}_{\text{(induced shot noise)}} + \underbrace{4N(kT_c)^2}_{\text{(chromatic noise)}} + \underbrace{Ne^2V^2\Gamma^2}_{\text{(transfer noise)}} \quad (9)$$

(*ii*) *Quantum case*

$$\overline{(W)^2} = \underbrace{\frac{(Nph\nu)^2}{2}\cdot\delta(\nu-\nu_0)}_{\text{(signal)}} + \underbrace{2N^3e^4\Gamma^2Z^2}_{\text{(induced shot noise)}} + \underbrace{4N(kT_c)^2}_{\text{(chromatic noise)}} + \underbrace{\frac{4}{\pi}Np(h\nu)^2 - N(1-\Gamma^2)p^2(h\nu)^2}_{\text{(transfer noise)}} \quad (10)$$

The symbols have the following meaning:

$\overline{(W)^2}d\nu$ = mean-square energy flow per unit time in an arbitrary frequency interval.
$N$ = number of electrons crossing the cavity per second
$e$ = charge of an electron
$V$ = peak voltage across the cavity
$\delta(\nu-\nu_0)$ = Dirac function centered on $\nu_0$ signifying the signal "line" in the spectrum
$\Gamma^2$ = shot-noise reduction factor
$Z$ = effective shunt impedance of the cavity
$k$ = Boltzmann's constant ($1.37\times10^{-23}$ joules per degree)
$T_c$ = effective temperature of electron stream as defined by the spread of its energy spectrum
$p$ = ratio of peak voltage to "quantum voltage"

$$\left(\frac{V}{\frac{h\nu}{e}} = \frac{V}{V_q}\right)$$

$h$ = Planck's constant ($6.55\times10^{-34}$ joule second)
$\nu$ = frequency in cps.

The above expressions have been obtained by deriving the appropriate correlation function for the various terms. The frequency spectrum is then obtained as the Fourier inversion of the correlation function. This procedure, now a well-known tool in stochastic analysis, is based on the theorem of Wiener and Khintchine (Rice[4]). The transfer noise terms can be interpreted as "shot" fluctuations of the units of energy transfer; that is to say $\sim eV$ in the classical case and $h\nu$ in the quantum case.

The transfer fluctuations in the latter case may be likened to the problem of emission fluctuations in a photo cell; in that case we are dealing with fluctuations in the rate of arrival of incident photons and fluctuations arising from the fact that the probability of emission is less than unity.[5] If the photons arrived perfectly regularly, then this corresponds to $\Gamma^2=0$ in the above equation. If, however, the probability of emission is small, corresponding to $p\ll1$, then the rate of emission of photoelectrons is essentially random corresponding to neglect to the last term of (10). Formally, these problems are both analogous to the familiar phenomenon of partition noise in a positive-grid tube where the general formula for current fluctuations in the screen current is given by

$$\overline{(\delta i_{SG})^2} = 2eI_{SG}\cdot\frac{\Gamma^2I_{SG}+I_A}{I_{SG}+I_A} \quad (11)$$

which may be written more fundamentally, for comparison with (10)

$$\overline{(\delta i_{SG})^2} = 2e\{p - p^2(1-\Gamma^2)\}I_{\text{total}} \quad (12)$$

where $p$ is the probability of capture of an electron by the screen grid.

Reverting to (9) and (10), it is clear that the signal power transferred in both cases is identical since $p=eV/h\nu$. The first two noise terms in either expression are the same. Therefore, for any significant difference between the two cases to be observable these must not be large compared with the transfer noise.

If we take the following values

$$I(=Ne) \approx 10^{-6}\text{ amp}$$
$$Z = 10^3\ \Omega$$
$$V \approx \frac{1}{10}V_q = 1.2\times10^{-5}\text{ volt} \quad (\therefore\ p = 0.1)$$

then the noise in the two cases may be written

$$\underbrace{3.2\times10^{-31}\cdot\Gamma^2}_{\text{(shot noise)}} + \underbrace{5\times10^{-33}\cdot\Gamma^2}_{\text{(chromatic noise)}} + \underbrace{\begin{cases}2.4\times10^{-35}\,\Gamma^2 & (9a)\\ 3.2\times10^{-34} & (10a)\end{cases}}_{\text{(transfer noise)}}$$

## III. Conclusion

It is thus evident that the classical transfer noise wil *always* be entirely negligible, while it would be necessary to achieve extreme limiting conditions $\Gamma^2<\sim.01$ $T<\sim1°K.$) for the quantum transfer noise to become perceptible. It is perhaps worth noting, however, tha for *normal* operating conditions with such a beam current—say $T\sim10^{30}$K.; $\Gamma^2\sim.1$), the chromatic nois ($5\times10^{-27}$) would apparently dominate the induce shot-noise power ($3\times10^{-32}$). Such a case does not i fact usually arise in practice since the shot noise in creases with the cube of the current while the chromati noise only increases linearly.

[4] S. O. Rice, "Mathematical analysis of random noise," *Bell Sys. Tech. Jour.*, vol. 23, pp. 282–333, July, 1944; and vol. 24, pp. 46–157; January, 1945.

[5] One might also have to recognize the possibility of fluctuations in the delay between arrival of a photon and departure of an electron.

# Design Procedures for Pi-Network Antenna Couplers*

LEO STORCH†

*Summary*—**The design of reactive pi-networks for transforming a wide range of complex load impedance into a fixed resistance shunted by a tuned circuit is subjected to a thorough investigation. A very significant result is the complete analogy which is established between the analysis and design of the pi-network and the equivalent manipulation of a group of simple geometrical figures.**

## 1. Introduction

THE AUTHOR was confronted recently with the task of designing an antenna-coupling network for a wide range of antenna impedance and frequency. A search of the literature of recent years disclosed the lack of a satisfactory account concerning coupling networks for the case of complex load impedances. It is the object of this paper to present the principal results of a comprehensive study of reactive pi-networks performing the functions of an antenna coupler.

The design equations are derived in compact form, convenient for use. It is then shown how to express the properties and behavior of the network by a set of circular and parabolic impedance contours. The design process is thereby reduced to the equivalent problem of finding a satisfactory arrangement of these geometrical loci. The pictorial map provides a powerful tool for the choice of the network configuration and determination of optimum design parameters. The directness of approach and economy of effort in comparison to conventional methods are particularly in evidence when numerous values of antenna impedance and frequency (e.g. aircraft antennas) are involved.

Since the primary application is probably in matching the impedance of the antenna to that of the power amplifier of a transmitter, the terms "antenna coupler" and "antenna impedance" are used exclusively. Such a network finds use, of course, wherever it is necessary to transform a complex load impedance into a certain resistance, e.g., matching to a generator with resistive source impedance, and all the design procedures are directly applicable in such a case.

## 2. Analytical Design Procedure

For satisfactory operation of a radio transmitter, the load presented to the output stage should be a resistance shunted by a parallel-tuned circuit. Since this resistance $R_p$ acts as plate-load for the power-amplifier tube, its value is determined by the tube characteristics and should be the same for all frequencies of operation. The tuned or "tank" circuit, which functions as an energy reservoir, is essential in producing a sinusoidal output signal in spite of class C operation. The values of its two reactances (Fig. 1(a)) depend on the desired value of "loaded $Q$" ($Q_L$). Since the antenna impedance $Z_A$, which symbol may also stand for the input impedance of the transmission line feeding the antenna, will hardly ever have the required value, it is necessary to transform it to this value by means of an antenna-coupling network.

The three-element, reactive, pi-network is a suitable choice for the antenna coupler. Economical in the number of required components, it is capable of handling an extremely wide range of impedance, allows close control of the loaded $Q$, and contributes to harmonic suppression when the shunt arm on the input side is capacitive.

### 2.1 Shunt Arms $X_1$ and $X_3$

The problem is to make the circuit of Fig. 1(c) equivalent to the loaded tuned circuit of Fig. 1(a) by the proper design of the nondissipative pi-network.[1]

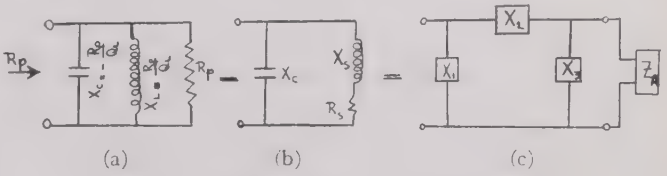



Fig. 1—Antenna-coupler equivalent circuits.

Because of unavoidable stray capacitances to ground, and in order to contribute to the suppression of harmonics, let the input shunt arm be made capacitive:

$$X_1 = X_c = -\frac{R_p}{Q_L}. \tag{1}$$

Comparing Fig. 1(a) and Fig. 1(b)

$$R_s + jX_s = \frac{R_p \cdot \dfrac{jR_p}{Q_L}}{R_p + \dfrac{jR_p}{Q_L}} = \frac{R_p(1 + jQ_L)}{1 + Q_L^2} \tag{2}$$

or

$$R_s = \frac{R_p}{1 + Q_L^2} \cong \frac{R_p}{Q_L^2}$$

$$X_s = \frac{Q_L R_p}{1 + Q_L^2} \cong \frac{R_p}{Q_L} \tag{3}$$

* Decimal classification: R320.51×R143. Original manuscript received by the Institute, February 18, 1949; revised manuscript received, May 20, 1949.

† Radio Corporation of America, Camden, N. J.

[1] Residual dissipation in the coils can be accounted for by adjusting $R_s$ in (Fig. 1(c)), if desired.

since $1+Q_L^2 \cong Q_L^2$ ($Q_L$ is about 10 to 20).

Proceeding from Fig. 1(b) to Fig. 1(c):

$$R_s+jX_s=\frac{Z_A\cdot jX_3}{Z_A+jX_3}+jX_2$$

$$=\frac{R_AX_3^2+jR_A^2X_3+jX_AX_3(X_A+X_3)}{R_A^2+(X_A+X_3)^2}+jX_2. \quad (4)$$

Solving the real part of (4),

$$R_s=\frac{R_AX_3^2}{R_A^2+(X_A+X_3)^2}, \quad (5)$$

for $1/X_3$ and inverting

$$X_3=\frac{R_e}{-\frac{X_A}{R_A}\pm\sqrt{\frac{R_e}{R_s}-1}} \quad (6)$$

where

$$R_e=\frac{R_A^2+X_A^2}{R_A} \quad (7)$$

the equivalent, parallel-resistance component of $Z_A$.

Since $X_3$ must be real, it is necessary that

$$R_e \geqq R_s. \quad (8)$$

A graphical representation of this restriction, which hardly results in any practical difficulties, since usually $R_e \gg R_s$, is given in section 3.1. When (8) is satisfied, (6) generally supplies two possible-values for $X_3$. There will be both an inductive and a capacitive solution when

$$\left(\frac{R_A^2+X_A^2}{R_AR_s}-1\right)>\frac{X_A^2}{R_A^2}$$

or

$$R_A > R_s. \quad (9)$$

But when $R_A<R_s$, both solutions of $X_3$ are reactances of opposite type to $X_A$.

*2.2 Series Arm $X_2$*

From the imaginary part of (4), after eliminating $X_3$ by (6) and setting $X_s=-X_1$ by (3) and (1):

$$X_2=-\left[X_1\pm\sqrt{R_s(R_e-R_s)}\right]. \quad (10)$$

The choice of either the plus or minus sign in both (6) and (10) supplies a matched pair of values. The "minus" pair is referred to as $X_2'-X_3'$ and the "plus" pair as $X_2''-X_3''$.

*2.3 Simplification of the Equations for $X_3$ and $X_2$*

For values of $Z_A$ not in the vicinity of quarterwave resonance or its odd multiples

$$R_e-R_s=\frac{R_A^2+X_A^2}{R_A}-R_s\cong\frac{X_A^2}{R_A}$$

usually is a very good approximation.

In that case

$$X_3\cong\frac{X_A}{-1\pm\sqrt{\frac{R_A}{R_s}}} \quad (11)$$

$$X_2\cong-\left[X_1\pm\frac{X_A}{\sqrt{\frac{R_A}{R_s}}}\right]. \quad (12)$$

Equations (11) and (12) reduce the labor of numerical calculations substantially over a wide range of frequency.

## 3. Impedance Loci and Geometrical Design Procedure

*3.1 The $X_3$ Loci*

In section 2, the solution of pi networks to transform specified antenna impedances into a resistance $R_p$ has been obtained. The converse problem of determining what values of $Z_A$ can be matched by a given range of $X_3$ is also of great practical importance when a wide range in antenna impedance is involved.

*3.1.1 The $P_1$ Parabola.* Equation (5) can be written as

$$R_A^2-\frac{R_A}{R_s}\cdot X_3^2+(X_A+X_3)^2=0$$

or

$$\left(R_A-\frac{X_3^2}{2R_s}\right)^2+(X_A+X_3)^2=\left(\frac{X_3^2}{2R_s}\right)^2. \quad (13)$$

This circle in $R_A-X_A$ co-ordinates represents the locus of all $Z_A$'s that require the value of $X_3$ given by the negative of the ordinate of the center (Fig. 2). It is tangent to the $X_A$-axis and has the center at

$$R=\frac{X_3^2}{2R_s}, \qquad X=-X_3.$$

Eliminating the parameter $X_3$, there follows

$$X^2=2R_s\cdot R. \quad (14)$$

The centers of all impedance circles (13) lie on the parabola $P_1$ of (14), which is fixed as long as $R_s$ is constant.

Although $X_3$ is unchanged, $X_2$ varies in accordance with (10) as $Z_A$ moves around any of the circles (13).

*3.1.2 Graphical Solution for $X_3$.* In order to solve (6) graphically, it is only necessary to find the circles (13) which pass through the given $Z_A$. Their centers lie on parabola $P_2$

$$(X - X_A)^2 = 2R_A \cdot \left(R - \frac{R_A}{2}\right) \tag{15}$$

since they must be equidistant from the $X$-axis and the point $Z_A$. Consequently, the two points of intersection of $P_1$ and $\overline{P}_2$ (Fig. 2) are the centers of the two circles which pass through $Z_A$ and thereby determine the two possible values of $(-X_3)$. Actually, parabola $\overline{P}_2$ need not be drawn, since the two desired centers can be located very rapidly on $P_1$ by trial and error with the help of a compass.

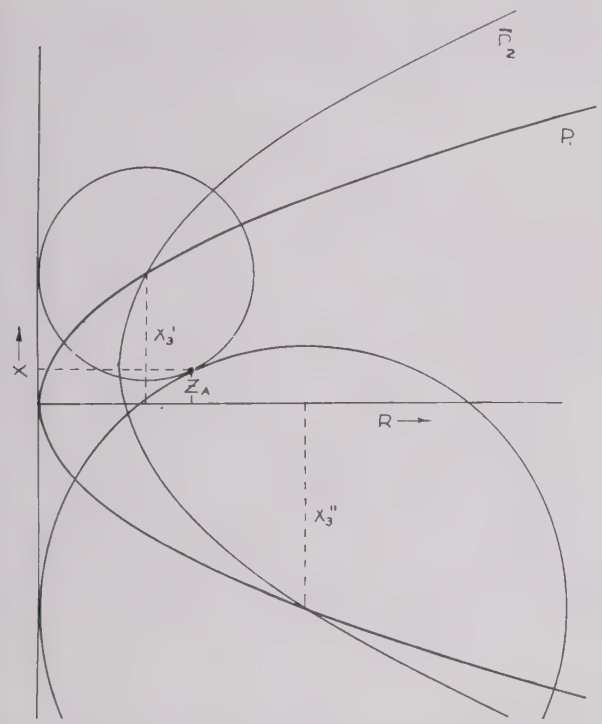



Fig. 2—Geometrical properties of $X_3$ solution.

*3.1.3 Matching Region of $Z_A$ for $X_3$ Variable Between Specified Limits.* From (13) can be deduced the region of the $Z_A$ plane which can be matched properly when $X_3$ is varied between assigned limits. It consists of the area swept out by the circles (13) as the parameter $X_3$ varies from the lower to the upper limit.

Part of the boundary is an arc of circle $C_1$ (Fig. 3), to which all circles $C_2$ of (13) are tangent. By (14), the directrix of $P_1$ is $R = -(R_s/2)$ and its focus is at $(R_s/2, 0)$. Since all $C_2$ circles are tangent to the $X$ axis, $R_s/2$ short of the directrix, they also extend to within $R_s/2$ of the focus. Consequently, the circle $C_1$ with radius $R_s/2$ and centered at $(R_s/2, 0)$ is tangent to all the $C_2$ circles. Fig. 4 shows how to find the complete boundary by locating the transition (tangency) points $T_1 - T_4$ and joining the three circle arcs and a segment of the $X$ axis; the shaded island between the intersecting arcs of the two $C_2$ limit circles is excluded from the matching region.

Since none of the $C_2$ circles crosses the boundary of $C_1$, its area is prohibited to $Z_A$. Since the equation of $C_1$ is

$$\left(R_A - \frac{R_s}{2}\right)^2 + X_A^2 = \frac{R_s^2}{4}, \quad \text{or}$$

$$R_A^2 + X_A^2 - R_s R_A = 0 \tag{16}$$

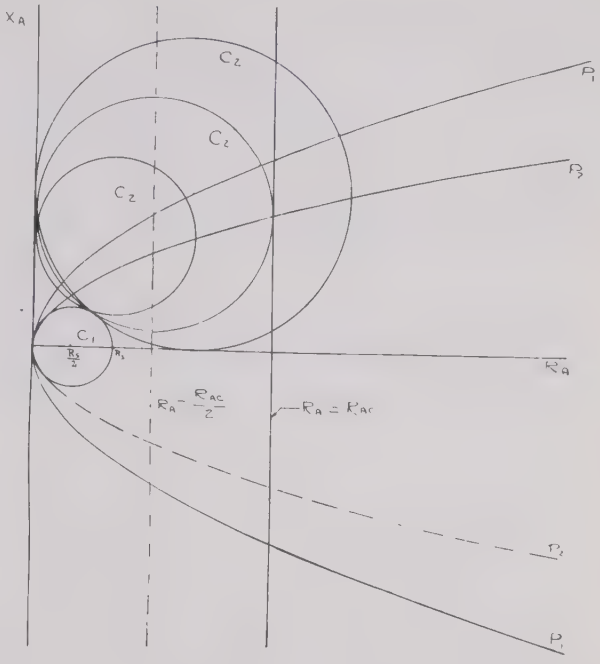



Fig. 3—The $C_2$ family of circles for $X_3$ and the $P_2$ locus.

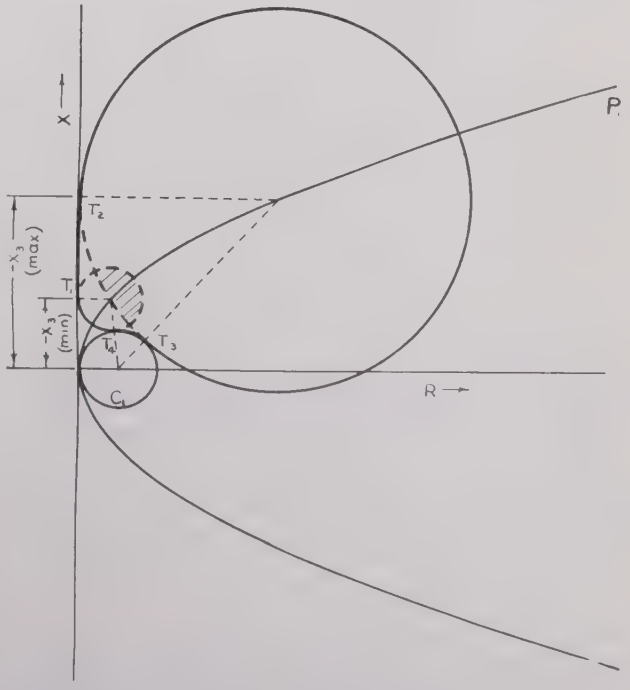



Fig. 4—$Z_A$ matching region for given range of $X_3$.

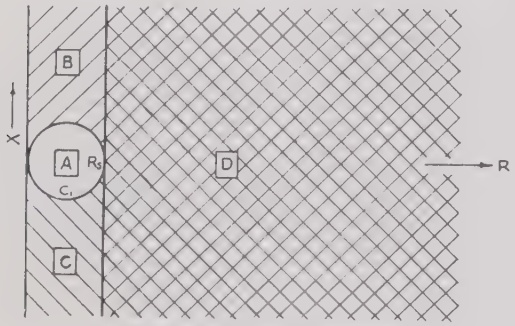
this restriction amounts to

$$\frac{R_A^2 + X_A^2}{R_A} - R_s \geqq 0, \quad \text{or} \quad R_e \geqq R_s. \tag{17}$$

This is identical with (8), represented graphically by the exclusion of $Z_A$ from within circle $C_1$.

*3.1.4 Matching Regions for Inductive or Capacitive $X_3$ Shunt Arm (Limits 0 and $\infty$).* Evidently, letting $X_3$ vary from 0 to $-\infty$ in Fig. 4 should provide a graphical illustration of the totality of values $Z_A$ may assume when $X_3$ is capacitive. The circle for $X_3$ min $=0$ is obviously the origin. The $X_3 = \pm\infty$ circle reduces to the straight line $R_A = R_s$, which follows by setting the denominator of (6) equal to zero.

Therefore, any $Z_A$ located in regions $B$ and $D$ of Fig. 5 can be matched by a capacitance of required value in the $X_3$ arm. In the inductive case, the matching area consists of regions $C$ and $D$, which is obtained by reflection about the axis of reals. This completes the geometrical representation of (6), (8) and (9) concerning the $X_3$ arm.




| REGION | FOR EVERY $Z_A$, $X_3$ HAS |
|---|---|
| A | NO MATCH POSSIBLE |
| B | TWO CAPACITIVE SOLUTIONS |
| C | TWO INDUCTIVE SOLUTIONS |
| D | ONE CAPACITIVE AND ONE INDUCTIVE SOLUTION |

Fig. 5—Possible $X_3$ solutions.

*3.1.5 Characteristics of the $X_3$ Arm.* In terms of Fig. 5, $X'_3$ is capacitive in $B$ and $D$ and inductive in $C$, while $X_3''$ is capacitive in $B$ and inductive in $C$ and $D$. On the boundary of $C_1$, there is only one solution $X_3 = (R_A^2 + X_A^2)/-X_A$ since $R_e = R_s$. Along $R_A = R_s$ one solution is $X_3 = (R_A^2 + X_A^2)/-2X_A$ and the other is $\infty$ (an open circuit).

*3.2 The $X_2$-Loci*

*3.2.1 Graphical Solution for $X_2$ ($C_{12}$ Circles).* Evidently, $X_2$ in (10) is constant when $R_e$ is fixed, $X_1$ and $R_s$ being constants for a given problem. Writing (7) as

$$R_A^2 + X_A^2 - R_A R_e = 0$$

or

$$\left(R_A - \frac{R_e}{2}\right)^2 + X_A^2 = \frac{R_e^2}{4} \tag{18}$$

it is seen to be the equation of a circle, which has a diameter $R_e$, passes through the origin, and has its center on the $R_A$ axis (Fig. 6). From similar triangles, as it is

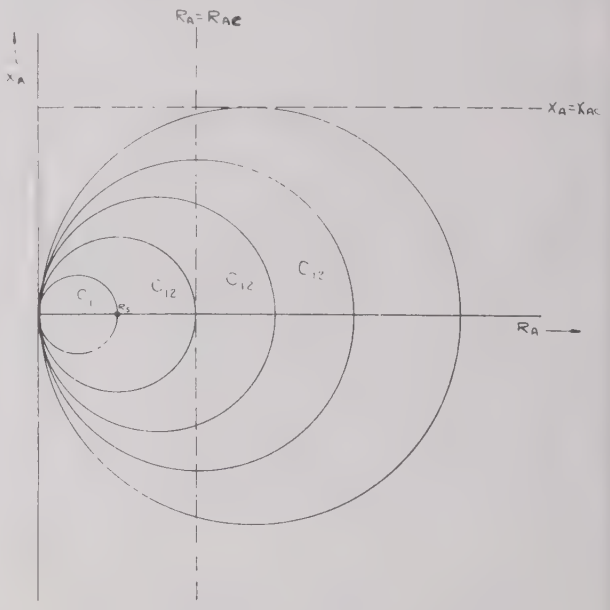



Fig. 6—The $C_{12}$ family of circles for $X_2$.

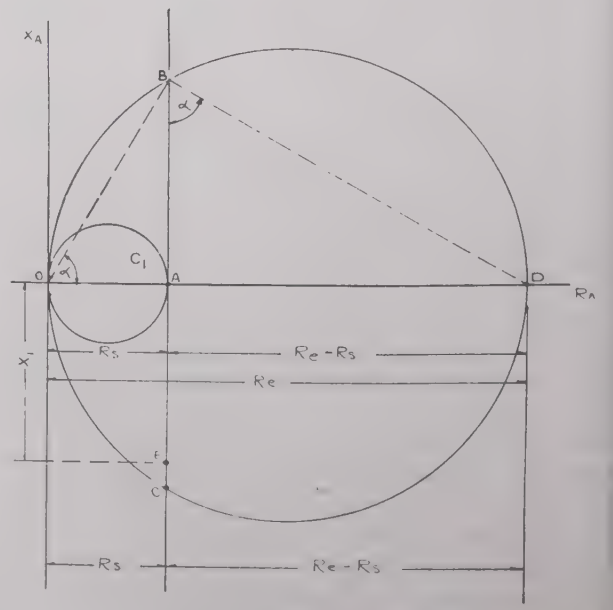



Fig. 7—Geometrical properties of $X_2$.

shown in Fig. 7.

$$\sqrt{R_s \cdot (R_c - R_s)} = \overline{AB} = |\overline{AC}|. \tag{19}$$

Consequently, the two solutions of $X_2$ can be identified as

$$X_2' = \overline{EB}, \qquad X_2'' = \overline{EC}. \tag{20}$$

The $X_2$ values for a given $Z_A$ can be located graphically as follows:

(a) Find the $C_{12}$ circle which passes through the given $Z_A$. The bisector of the $Z_A$ vector intersects the $R_A$ axis at its center.

(b) Move around this circle to locate the two points of intersection with the line $R = R_s$ (points $B$ and $C$ in Fig. 7).

(c) The $X_2$ values are the vertical segments along $R = R_s$ measured from $X = X_1$ ($E$) to these two points. $X_2'$ is directed upwards and is inductive. $X_2''$ may be inductive or capacitive, depending on $C$ being above or below $E$. It is zero (a short circuit) when $C$ coincides with $E$.

*3.2.2 Characteristics of the $X_2$ Series Arm.* Important conclusions can be drawn from (10) and Fig. 7. $X_2'$ is an inductive reactance larger than $|X_1|$ for any value of $Z_A$, while $X_2''$ may be inductive, a short circuit, or capacitive. When $X_2''$ is zero (short circuit), the equivalence of Fig. 1(a) and Fig. 1(c) requires that

$$R_c = R_p \tag{21}$$

must hold. This also follows from a comparison of the first part of (4), $X_2 = 0$, with (2). Therefore, the $\overline{C}_{12}$ circle, for which $R_c = R_p$, constitutes a border line for values of $X_2''$. Inside, $R_c < R_p$ and $X_2''$ is inductive by (10), while outside of it $X_2''$ is capacitive since $R_c > R_p$. As a practical consideration, it is desirable to restrict the choice of the $X_2''-X_3''$ pair to $Z_A$ values inside the $\overline{C}_{12}$ circle. Otherwise, the $X_2$ arm may require excessively large capacitances for $Z_A$'s just outside of the $R_c = R_p$ circle. The limit circle $C_1$, from which $Z_A$ is excluded by (17), turns out to be the smallest allowable $C_{12}$ circle with $R_c = R_s$.

*3.2.3 Matching Region of $Z_A$ for $X_2$ Variable Between Specified Limits.* Any $Z_A$ lying within the crescent-shaped area between the two $C_{12}$ circles corresponding to $X_2$ min and $X_2$ max can be transformed into $R_p$, provided $X_3$ takes on the necessary values. It follows from the previous section that when $X_2$ may be any inductive reactance, $0 < X_2 < \infty$, any $Z_A$ in the right-half plane outside the $C_1$ limit circle can be matched properly. Also, when $X_2$ may be any capacitive reactance, but is not allowed to become inductive, $0 > X_2 > -\infty$, any $Z_A$ outside the $\overline{C}_{12}$ circle ($R_c = R_p$) may be matched properly.

Knowing how to obtain the matching regions when $X_2$ and $X_3$ separately vary between specified limits, any $Z_A$ lying within the area common to both of the regions can be matched properly without $X_2$ or $X_3$ exceeding its limits.

## 4. Minimum and Maximum Values of $X_2$ and $X_3$

When numerous values of $Z_A$ are involved, their plot on the impedance plane will usually form a series of curves or cover a certain area. The extreme values of $X_2$ and $X_3$ can be deduced directly from each pair of $C_2$ and $C_{12}$ circles tangent to it from the outside and inside (or passing through the extreme tip in case of a curve).

This geometrical approach will be outlined in connection with the rectangular grid in the $Z_A$ plane. Lack of space does not permit including the complete derivation and other interesting aspects of this method.

### *4.1 Impedance Locus: $Z_A = R_{A_c} + jX_A$ ($R_{A_c}$ fixed)*

The $C_{12}$ circle tangent to this vertical line is determined by $R_c = R_{A_c}$ (Fig. 6). Inserting this value in (10) leads to $L_2'$ min and $L_2''$ max or $C_2''$ max, depending on $R_{A_c} < R_p$ or $R_{A_c} > R_p$, in terms of the operating frequency. When $R_{A_c} < R_s$, the smallest $R_c$ occurs at the intersection with circle $C_1$ and is $R_s$, so that $\omega L_2'$ min-$\omega L_2''$ max $= -X_1$.

Since the $C_2$ circles tangent to the $Z_A$ locus must also be tangent to the $X_A$ axis, the abscissa of the center is $R_{A_c}/2$ (Fig. 3). Therefore, by (14) and the geometry of the figure

$$X_3 = \pm \sqrt{R_s R_{A_c}} = -X_A. \tag{22}$$

Letting $R_{A_c}$ vary from 0 to $\infty$, the $Z_A$ values requiring minimum $|X_3|$ lie on parabola $P_2$ (Fig. 3) by (22):

$$X_A^2 = R_s R_A. \tag{23}$$

$C_3'$ max is obtained from the upper branch and $L_3''$ min from the lower one. Also, $C_3''$ max and $L_3'$ min in the strip $R_A < R_s$ occur at the intersection with the upper and lower halves respectively of the $C_1$ circle.

### *4.2 Impedance Locus: $Z_A = R_A + jX_{A_c}$ ($X_{A_c}$ fixed)*

From Fig. 6, $R_c$ min$/2 = |X_{A_c}|$ when $|X_{A_c}| > R_s/2$, which leads to an extreme value for $L_2'$ and $L_2''$ or $C_2''$. For $|X_{A_c}| < R_s/2$, $R_c$ min $= R_s$.

The pertinent $|X_3|$ min values follow from the tangency equations

$$\frac{X_3^2}{2R_s} = X_{A_c} + X_3, \quad \text{for} \quad X_{A_c} > 0 \tag{24}$$

$$\frac{X_3^2}{2R_s} = -(X_{A_c} + X_3), \quad \text{for} \quad X_{A_c} < 0 \tag{25}$$

since the vertical distance from the line $X_A = X_{A_c}$ to the center of a tangent $C_2$ circle is equal to its radius $X_3^2/2R_s$.

Letting $X_{A_c}$ vary from $-\infty$ to $+\infty$, the $Z_A$'s requiring $|X_3|$ min lie on two parabolas $P_3$ and $P_4$ (Fig. 8),[2] such that the solidly drawn segments apply to $C_3'$ max, and their reflections about the axis of reals to $L_3''$ min.

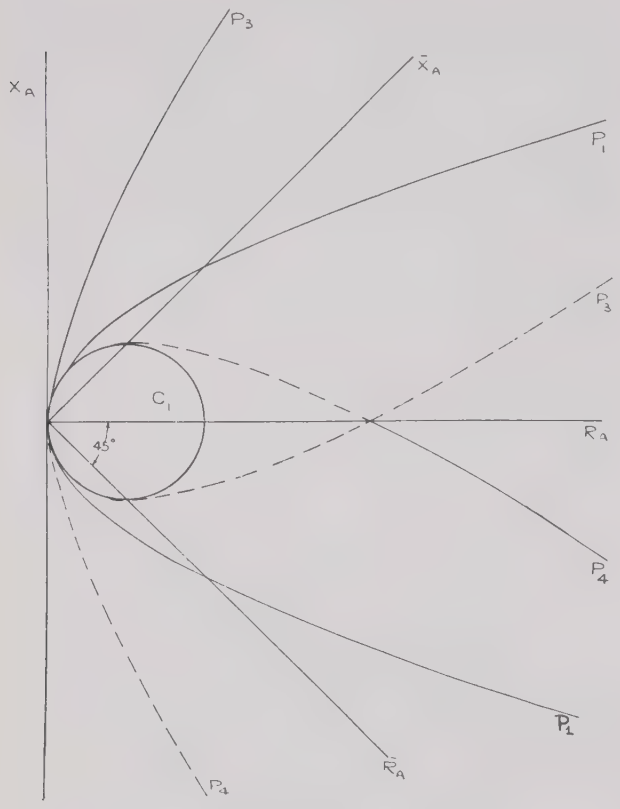



Fig. 8—The parabolic loci $P_3$ and $P_4$.

A vertical line through a point on these loci with ordinate $X_{A_c}$ intersects the applicable branch of $P_1$ at $|X_3|$ min, valid for the whole $Z_A$ locus $X_A = X_{A_c}$. The apex of $P_3$ is at $(R_s/8, (-3)/8\ R_s)$, its focal distance is $R_s/4\sqrt{2}$, and its axis of symmetry is inclined at 45° with respect to the axis of reals. $P_4$ is the reflection of $P_3$ about the axis of reals.

$C_3''$ max and $L_3'$ min are obtained on approaching the $X_A$ axis, and $X_3$ min $= -X_{A_c}$.

Since any area in the $Z_A$ plane can be viewed as a bounded portion of the rectangular grid, it is instructive to be familiar with the behavior of $X_2$ and $X_3$ along the $Z_A$ loci $R_A = R_{A_c}$ and $X_A = X_{A_c}$.

## 5. Conclusions

Complete correspondence is established between the behavior of the pi-network antenna coupler and a set of simple geometrical figures. This reduces the design process to an equivalent problem in elementary analytic geometry, with the great advantage that the behavior of all design factors under any imposed set of conditions can be clearly visualized and studied with ease. Thus the way is opened to an optimum design in terms of the requirements (desired pi-network configuration, value of $Q_L$, restrictions on size and ratings of components, etc.). Even when numerous antenna impedance values are involved, numerical calculations are reduced to a minimum since the values required for the components follow directly from the tangency points of the geometrical representation. This contrasts very favorably with the laborious, point-by-point computations of the conventional design procedure, which, in addition, offers no assurance of obtaining the complete range of the components or devising the most economical design.

Equations (1), (3), (6), (7), and (10) with the approximate expressions (11) and (12) provide, in convenient form, the means for calculating and checking the reactance values where required.

Due to the lack of space, only the basic aspects of this geometrical technique could be presented. The author hopes to cover ramifications and some interesting applications to aircraft antennas in another paper.

[2] Derived by substituting $X_3 = \sqrt{2R_sR_A}$ in (24) and (25), squaring, and transforming to principal axes.

# Correction

It has been brought to the attention of the editors that an inadvertant error was made in the professional affiliations of Ronold King and K. Tomiyasu, authors of the paper, "Terminal Impedance and Generalized Two-Wire-Line Theory," which appeared in the October, 1949, issue of the Proceedings of the I.R.E. Dr. Tomiyasu has joined Sperry Gyroscope Company, Great Neck, L. I., N. Y., leaving Harvard University, where Dr. King is still engaged as a professor of applied physics.

# The Application of IF Noise Sources to the Measurement of Over-all Noise Figure and Conversion Loss in Microwave Receivers*

LESLIE A. MOXON†

*Summary*—The "noise diode" technique is now well-established for the absolute measurement of receiver noise figure at frequencies up to about 300 Mc. A method is described of extending this technique to much higher frequencies, using a frequency changer to produce the required rf test signal from an if noise source. An experimental procedure has been developed which enables the signal level to be accurately evaluated, subject to such limitations as those of Dicke's reciprocity theorem which are of little practical significance for the applications so far considered. As in the low-frequency case, measurements are in general independent of receiver bandwidth, there is no stray radiation problem, and the receiver output indicating device may follow any law within wide limits.

The necessary components are easy to construct and can be calibrated without the use of additional apparatus. The system is particularly well suited to mixer crystal measurements since both conversion loss and over-all noise figure can be measured with equal facility, and the latter is readily analyzed in terms of conversion loss and noise ratio.

## I. Introduction

THE TEMPERATURE-LIMITED diode is now well-established as a method of measuring receiver noise figure at frequencies up to about 300 Mc, and possesses the merits of extreme simplicity and high accuracy. The diode anode current flows through a resistance $R$ and (the diode impedance being normally much greater than $R$) the combination forms a signal generator of output impedance $R$ and available power $eIBR/2$ where $e$ is electron charge, $I$ the anode current, and $B$ the receiver bandwidth. If $I$ is given the value required to double the noise power in the receiver, the receiver noise factor defined with respect to a temperature of 290° K, is given by the well-known expression

$$N = 20IR. \qquad (1)$$

Some success[1] has been obtained in extending this technique up to about 3,000 Mc but suitable diodes are difficult to construct, corrections have to be made for transit time, and the absolute accuracy so far obtained is relatively poor. This paper describes a new technique of measurement[2] which has been evolved using an if noise source in conjunction with a mixer to provide an accurately known microwave rf signal for measurement of noise figure and mixer conversion loss.

The basic principle is as follows. Given two identical mixers, a known amount of if noise can be converted to rf and back again to if, the if output of the second mixer being measured by means of another noise generator connected across the output terminals to provide a reference signal. The total decibels loss in the double frequency-changing process being thus determined, it is merely necessary to divide by two to find the loss in either mixer subject to the assumption of reciprocity which will be justified later. From the losses in the first mixer and the known if noise level we can determine the rf noise level. Instead of two identical mixers, any three mixers may be used and the total loss measured for each of the three possible combinations; solution of the three equations gives the loss in each of the mixers. In practice, variations between mixers are almost entirely due to crystals so that it is only necessary to interchange crystals, and the full procedure is necessary only for the initial calibration, after which either noise-factor or conversion loss can be determined from a single reading of diode current.

There are certain practical difficulties to be overcome; for example, attenuation must be inserted between the mixers to enable them to be adjusted independently and, (preferably assisted by directive feeds) to confine each local oscillator to its own mixer. The amount of attenuation required is fairly small (10–15 db) but makes it advisable to use an amplifier between the first noise diode and mixer. To simplify the theory, the two local oscillators are tuned twice the if apart so that a single noise sideband is used.

This technique retains in comparison with continuous-wave signal generator methods of noise figure measurement many of the main advantages of the lower frequency diode noise sources; for example, there is no stray radiation problem, accurate knowledge of bandwidth is unnecessary, and difficulties connected with the indication of receiver output are minimized. The amount of attenuation required, and therefore the percentage accuracy with which it must be measured, is an order of magnitude less than in the cw signal generator case.

Another feature claimed for this technique is the readiness with which it lends itself to improvization. Given a receiver to be measured for noise factor, there is no need to have test equipment specially developed for

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† Royal Naval Scientific Service, Surrey, England.

[1] R. Kompfner, J. Hatton, E. E. Schneider, and L. A. G. Dresel, "The transmission-line diode as a noise source at centimetre wavelength," *Jour. IEE*, vol. 93, part IIIA, pp. 1436–1443, no. 9; March–May, 1946.

[2] Described in various unpublished reports dating from 1944, and briefly mentioned in an earlier publication (L. A. Moxon, *Wireless World*, January, 1947).

the purpose; the main requirements are a spare mixer and local oscillator, and the other items are easily constructed if not already at hand.

## II. Typical Layout and Experimental Procedure for Precision Measurements

Fig. 1 illustrates an actual arrangement intended primarily for 10-cm mixer crystal measurements, but readily adaptable for measuring the noise factor of other receivers, traveling-wave tubes, etc. In addition to the basic essentials outlined above, provision was made for the measurement of mixer noise ratio and if impedance. The rf circuitry employed waveguides throughout. The local oscillators were of the Heil type (CV230) and coupled to the mixers through variable attenuators and simple directive feeds giving about 6 db of directivity. The mixers were of a conventional waveguide type with double slug tuning and had a bandwidth of about 80 Mc for a standing-wave ratio better than 2.0 with most crystals. The if for both the receiver and the noise amplifier was 13.5 Mc the bandwidths being of the order of 1.5 and 10 Mc, respectively. The if noise figure was approximately 2 db, and the local oscillator contributed noise of the order of 0.05 to 0.2 units of crystal noise temperature ratio.

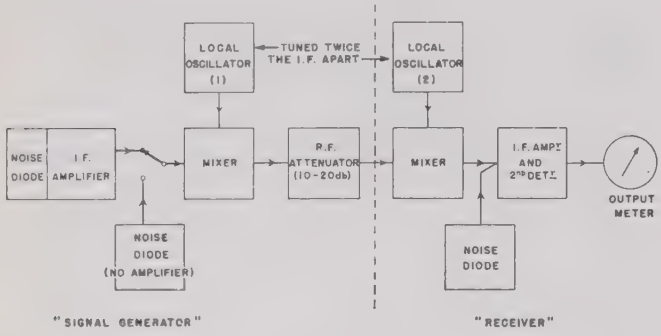


Fig. 1

### *The Noise Amplifier*

Let us first consider the case when the switch is in the lower position, i.e., no amplifier between noise source and mixer. The noise figure of the receiver is given by the usual expression

$$N_{rec} = L_{m2}(N_{if} + t - 1), \tag{2}$$

where $N_{if}$ is the if noise factor, $t$ is the mixer noise temperature ratio, and $L_{m2}$ the conversion loss. A noise figure $N'$ may be assigned to the entire system to the right of the switch, and is obviously given by

$$N' = N_{rec}L_{m1}L_a, \tag{3}$$

where $L_{m1}$ is the conversion loss of the first mixer and $L_a$ is the attenuation inserted between the mixers. If the noise source doubles the noise output power $P_{no}$ of the receiver when adjusted to a current $I_1$, $N'$ is given by $20I_1R$ in accordance with (1). The CV172 "noise diode" has frequently been run for short periods at 50 milliamps or more, and a load of about 400 ohms provides an impedance match for the average crystal; this corresponds to a value of 400 for $N'$. Lowest practicable values of $N_{rec}$ and $L_{m1}$ are of the order of 7 and 4 respectively, giving a permitted value of anything up to 400/28 or 11.5 db for $L_a$; this was just about sufficient from the point of view of preventing interaction between the mixers, and it was possible to work with a smaller change of receiver noise output, but there was not much in hand for dealing with anything short of the best possible performance, and an amplifier was therefore included. Using selected crystals it was possible to measure the insertion power gain $G_p$ directly by operation of the switch, but in less favorable circumstances it might be necessary to resort to more elaborate measures.

The bandwidth of the noise source should of course exceed that of the receiver but difficulties may be encountered if it is unduly wide; thus with the amplifier out of circuit an appreciable error was found due to noise generated at three times the desired intermediate frequency, which produced a sideband at the receiver image frequency. This effect was eliminated by means of a 40.5 Mc series-tuned circuit across the noise diode load, but was not observed at all on another occasion when working with a 45 Mc if, due presumably to the greater shunting effect of the mixer rf by-passing capacitance.

Two types of noise amplifier have been used, the first consisting of a single stage having an anode load of 400 ohms to match the crystal impedance. The noise diode was connected in parallel with the grid circuit, which was also loaded with 400 ohms, the value in this case being determined by bandwidth considerations. The second type, with which most of the measurements have been made, had similar input and output arrangements but used 3 tubes in an inverse feedback circuit employing a 65-ohm resistance common to the cathodes of the first and last stages, the voltage gain being very approximately the ratio of the resistances (400/65) and therefore relatively stable. The internal noise level of the feedback amplifier was rather high, equivalent to 3 ma of noise diode current, but this was easily measured and allowed for. Although the feedback circuit was satisfactory at 13.5 Mc, difficulties arose at higher frequencies owing to phase shifts caused by stray capacitances.

### *The Attenuator*

The attenuator consisted of two wedge-type sections, one variable and one fixed, calibrated by direct measurement of insertion loss. Attenuation should be sufficient to prevent the tuning of one mixer from affecting the other, and to ensure that the crystal current produced in either mixer by leakage from the local oscillator of the other does not exceed about 10–20 microamperes. If the latter condition is not satisfied, the second local oscillator may become appreciably modu-

lated with if noise via the first mixer, and errors can also be caused by noise-modulated power from the first local oscillator reaching the second mixer and combining there with the two noise sidebands to produce unwanted if output. Additional attenuation acts against the leakage power as well as against the various noise sidebands, so that the unwanted effects decrease more rapidly than the wanted noise and a simple check is therefore to increase the local oscillator power and remeasure the apparent insertion loss of the attenuator which should be unchanged. Most of the 10-cm measurements were made with $L_a$ equal to 14.5 db and with 6 db of directivity in each of the local oscillator feeds, the leakage effects being undetectable under these conditions.

*Evaluation of Conversion Loss and Noise Factor*

In order to evaluate the conversion loss it is necessary to know the available if noise output power $P_n$ from the second mixer. If $R_{m2}$ is the if output resistance of this mixer, and the noise diode connected across it is adjusted to a current $I_2$ such that it gives the same increase of receiver output as the current $I_1$ of the diode feeding the first mixer, $P_n$ is proportional to $I_2R_{m2}$, and defining mixer conversion loss as available power output/actual input power, we have the relationship

$$L_{m1}L_{m2}L_a = I_1R/I_2R_{m2}. \tag{4}$$

Perfect matching has been assumed between each mixer and the attenuator, and also between the first mixer (if impedance $R_{m1}$) and the load resistance of its noise diode. The easiest way to make $L_{m1}$ equal to $L_{m2}$ is to select crystals by comparison in the first mixer. Let $L_{m1}$ can then be evaluated from (4).

Adjusting $I_1$ to double $P_{no}$, we can substitute $20I_1R$ for $N'$ in (3) and obtain

$$N_{rec} = 20I_1R/L_{m1}L_a. \tag{5}$$

It was found that adjustment of the mixers for maximum power output usually gave a standing-wave ratio better than 1.5, and taking $R=400$ ohms the value of $R/R_{m1}$ or $R/R_{m2}$ lay between 0.7 and 1.4 for normal crystals at 0.5 ma rectified current, so that mismatch errors are unlikely to be appreciable. On the other hand, ignorance of $R_{m2}$, since this quantity enters directly into equation (4), could lead to an error of $\pm 1.5$ db in $L_{m1}L_{m2}$; i.e., with $L_{m1}=L_{m2}$ an error of 0.75 db in $L_{m1}$, and therefore in noise-figure measurements, would be likely. Measurement of $R_{m2}$ is therefore necessary. It is to be noted that $L_{m1}$, $L_{m2}$, $R_{m2}$, and to some extent the noise ratio, are dependent on the rf impedance presented to the mixer, not only at the signal but also at the image frequency.[3] It is therefore desirable to have a good match at both frequencies, and the appropriate value of of if should be employed in measuring $R_{m2}$, dc or lf bridge methods being unsuitable for accurate work.

If it is required to make measurements on, say, a number of crystals, the full process described above need only be carried out once. From inspection of (5) we see that the value of $I_1$ required (for example) to double the total noise power in the receiver is directly proportional to $L_{m1}$ and to $N_{rec}$. $I_1$ is also proportional to $L_{m2}$ if $t$ is constant, but changing the crystal in the second mixer alters $t$ as well as $L_{m2}$, and the simplest procedure is therefore to measure $L_{m1}$ for any crystal, the value for other crystals being determined by comparison in the first mixer. Similarly, to determine $N_{rec}$ the crystals are compared in the second mixer. If a noise amplifier is used, $I_1$ is of course replaced by the product of the power gain $G_p$ and the observed current. $L_{m2}$ may be obtained from (2), after $t$ and $N_{if}$ have been determined separately, but this is a more complicated procedure and, for a given crystal, $L_{m1}$ should be equal to $L_{m2}$.

*Measurement of the IF Impedance of the Mixer*

Fig. 2(a) illustrates the if input circuit used in most

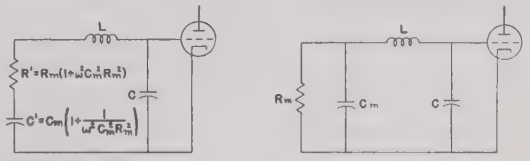


Fig. 2

of the measurements. At any given frequency it can be represented by the equivalent circuit of Fig. 2(b) by means of the following relationships:

$$R' = R_m(1 + \omega^2C_m^2R_m^2) \tag{6}$$

$$C' = C_m(1 + 1/\omega^2C_m^2R_m^2). \tag{7}$$

It is to be noted that $C'$ and therefore the tuning point of the circuit, is dependent on both $C_m$ and $R_m$, the slope $dC'/dR_m$ being a maximum, for a given value of $R_m$, when $R_m=1/\omega C_m$. When the value of $C_m$ was chosen to give minimum noise figure, $R_m$ and $1/\omega C_m$ were found to be of the same order, and to make use of this fact for measurement of $R_m$ it was only necessary to provide a calibrated tuning control on the input circuit, an if signal, and a sensitive resonance indicator.[4] For calibration, a range of small carbon resistors of known value was made up in crystal capsule form and inserted in place of the mixer crystal. The change of resonant frequency over the desired range of $R_{m2}$ was small, but with care it was possible to measure $R_{m2}$ to within about 5 per cent, leaving a possible error of the order of $\pm 0.1$ db in the determination of $L_{m1}$.

It is not always possible to satisfy the input circuit conditions required by this method, and there is a simple alternative.[5] The crystal is replaced by a set of

[3] E. W. Herold, R. R. Bush, and W. R. Ferris, "The conversion loss of diode mixers having image frequency impedance," Proc. I.R.E., vol. 33, pp. 603–609; September, 1945.

[4] Method attributed to E. E. Schneider.

[5] H. C. Torrey and C. A. Whitmer, "Crystal Rectifiers," Radiation Laboratory Series, Vol. 15, McGraw-Hill Book Co., New York, N. Y. page 230; 1948.

resistances as in the previous method, and the incremental noise output power for some fixed value of diode current is observed for each resistance. The larger the resistance, the greater the increment, and a calibration curve may be drawn accordingly. Since mixer noise affects only the total output level and not the increment, observation of the latter for any mixer crystal enables its if impedance to be read from the calibration curve.

*Noise Ratio Measurement*

In a standard method of noise ratio measurement, the mixer is coupled to the first if tube by a circuit which gives a more or less constant output impedance as the input impedance is varied. The receiver noise output is then dependent only on the noise ratio and not on the impedance of the mixer, and is proportional to the quantity $(N_{if}+t-1)$. $N_{if}$ is constant if the output impedance is constant and $t$ can therefore be evaluated from observation of the change of noise output obtained on replacing the mixer by a resistance $R_c$, which need not be exactly equal to that of the mixer. The required conditions for this method should be satisfied for the circuit of Fig. 2(b) when $R_m=1/\omega C_m$, but an experimental check revealed some second-order anomalies attributable to using a small capacity across $L$ as the tuning control, and to the effect of tuning on the phase relationship between tube shot noise and induced grid noise. With the tuning control adjusted for $R_c=400$ ohms and fixed, increase of $R_c$ from 300 to 550 ohms caused an increase of $N_{if}$ from 1.6 to 1.8 and a decrease of 10 per cent in output noise power, so that for accurate measurements by this method it was necessary to obtain a rough estimate of $R_{m2}$ and apply corrections.

Alternatively, if $R_{m2}$ is known accurately, we can increase the current $I_2$ of the diode connected across it until the total noise power is doubled; then if $R_{m2}$ has a noise ratio $t$, we have

$$N_{if} + t - 1 = 20I_2R_{m2}. \tag{8}$$

$N_{if}$ is found by making $t=1$, i.e., replacing $R_{m2}$ by an ordinary resistance, so that knowing $I_2$, $R_{m2}$ and $N_{if}$ we can obtain $t$.

Good agreement was obtained in practice between the two methods. It is of interest to note that if $(N_{if}+t-1)$ is determined by the first method, the value of $R_{m2}$ can be deduced from (8).

*Receiver Output Measurement*

The second detector of the receiver consisted of a low impedance diode (Type VR92), and the rectified current was used as an indication of noise output giving a linear law over at least the desired range of 0.5 to 1.5 volts. The diode characteristic has proved stable over a period of years and holds for most tubes of the same type after ageing to reduce the standing current. The if amplifier itself was linear up to the highest output level required. Initially the diode was replaced by a thermistor bridge, but this was found to be an unnecessary complication.

The output indicating device can usually be calibrated, whatever its law (provided this is independent of gain setting), by means of the noise source using the following procedure suggested by L. A. G. Dresel. Let receiver noise alone give an output reading $\theta_1$; to evaluate the noise factor $N$ from (1) it is necessary to know $I_x$, the diode current which produces noise equal to the receiver noise. Let a current $I_y$ increase the output to a reading $\theta_2$ and let the gain then be turned down so that $\theta_2$ is reduced to $\theta_1$; if the current is now increased to a value $I_z$ such that the output reading is again $\theta_2$, the ratio $r$ of $I_x+I_y$ to $I_x$ must be the same as that of $I_x+I_z$ to $I_x+I_y$. This leads to the relation

$$I_x = I_y^2/(I_z - 2I_y). \tag{9}$$

To obtain an accurate result from (9), $I_z/2I_y$ should not be less than about 2. This means that a value of at least 3 is desirable for $r$, and more diode current is required than if the detector law is already known, but this presents no difficulty with normal values of $N_{if}$.

## III. Practical Results and Discussion

The double-mixing noise generator technique was first employed as a means of obtaining an accurate comparison of two receivers at 10 cms after difficulties had been experienced with alternatives which included crystal and klystron noise generators and cw signal generators. As a method of relative measurement it was found simple to construct and use, and comparisons with two cw signal generators gave agreement on absolute level within 1 db. At this stage the technique had not been fully developed and the probability of errors of the order of $\pm 1$ db would have been fairly high. The cw signal generators were certainly no more accurate than this, so the agreement may have been largely fortuitous. Working at 3 cms, G. Eichholz and T. J. Buchanan obtained agreement between the new technique and other methods of measurement within about 0.25 db, but this again may have been largely due to chance, and it was realized that various possible sources of error required investigation. For this purpose a 10-cm measuring equipment was set up as illustrated in Fig. 1 and already described, facilities being provided for thoroughly checking each stage of the procedure. These included standingwave measuring equipment for checking rf matching, and a resonant cavity for measurement (by elimination) of local oscillator noise. The procedure described above was evolved mainly on the basis of experience with this equipment.

In one typical experiment, two dozen crystals were measured for conversion loss in both the first and the second mixers, and comparison of the results showed a scatter of the order of $\pm 0.5$ db which it was at first thought might be due to reciprocity failure; the worst pairs of crystals were therefore taken, the over-all con-

version loss was measured with one of the crystals in each mixer, and the crystals were then interchanged, and the measurements repeated. This was done several times with as much care as possible, and the total loss figures showed a spread of only about $\frac{1}{4}$ db. This means that, in general, reciprocity failure (if any) is not greater than $C \pm \frac{1}{8}$ db where $C$ is the same for all crystals of the type tested (British "Red Dot" silicon crystals). The number of crystals was not large enough for all possibility of more serious variations to be excluded, but evi-

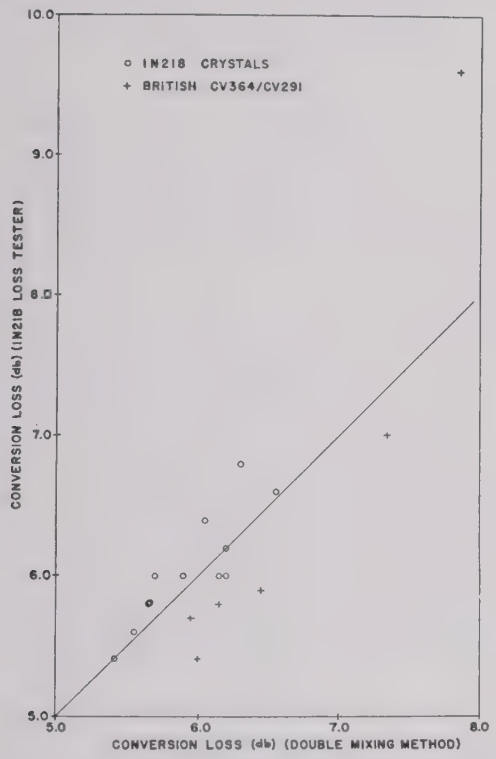


Fig. 3

dence from other sources[6] indicates (a) that for silicon crystals reciprocity failure is (by measurement) less than 0.2 db; (b) that any systematic or constant error $C$ is inappreciable; and (c) for germanium crystals reciprocity does not hold in general, although even in this case it would appear that calibration would be reasonably accurate if carried out with crystals selected to have the lowest possible loss.

Measurements of conversion loss by the above method on twelve 1N21B crystals and six British crystals which had previously been measured in one of the standard test sets[7] showed good agreement, as plotted in Fig. 3.

The crystal or diode mixer is commonly represented by an equivalent passive linear network, and reciprocity is implicit in any such representation. Reciprocity is also the basis of methods of conversion loss measurement based on the effect of if impedance on rf impedance or vice versa, such as that due to R. H. Dicke.[8] Dicke has pointed out, however, that full reciprocity holds only on certain assumptions, and a full discussion of this subject can be found elsewhere.[9] It is perhaps sufficient here to state that the necessary assumptions are not completely satisfied in practice, mainly because of variation of barrier capacitance with applied voltage. One would expect such an effect to be very variable from crystal to crystal, and the failure to observe any change in total loss when the crystals in the two mixers are interchanged confirms the more direct evidence, already mentioned, that reciprocity failure is of negligible practical significance for silicon crystals.

An apparent failure of reciprocity could arise from the practice of tuning the two local oscillators twice the if apart, assuming a lack of symmetry in the variation with frequency of the impedance presented to the rectifying contact of the crystal; this is because mixer conversion loss is dependent to some extent on the image frequency and (if appreciable) the harmonic frequency impedances seen by the nonlinear element. Lack of symmetry coupled with the staggering of oscillator frequencies means that these impedances can be different for the two mixers, even though the latter are physically identical. This effect should be detectable by comparing the over-all losses for the two possible tuning positions of each local oscillator in turn, but has not so far been observed.

## Acknowledgment

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[6] See pp. 125–127 and 212 of footnote reference 5.

[7] For the measurements in the 1N21 loss tester, and permission to publish them, the author is indebted to the Director, Naval Research Laboratory, Washington D. C.

[8] See page 203 of footnote reference 5.

[9] See chapter 5 of footnote reference 5.

# The Effect of Antenna Size and Height Above Ground on Pointing for Maximum Signal*

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*Summary*—During April, 1947, the Electrical Engineering Research Laboratory of The University of Texas made measurements of the variation of signal strength and phase of 3.2-centimeter radio waves with heights up to 200 feet for a 27-mile desert path in Arizona.[1,2]

This paper presents the results of a study of the vertical angles-of-arrival which would be indicated by pointing antennas of various sizes and at various heights for maximum signal strength in three of these measured fields.

A comparison is also made of the response of the antennas for various angles of tilt in these measured fields with the response of the antennas in an assumed field made up of two plane waves components.

## I. Introduction

THE PURPOSE OF this investigation is to study the effect of antenna size and height above ground on the apparent angle-of-arrival of the radio wave as indicated by pointing the antenna for maximum signal.

The study is made by determining the angle at which maximum signal is received as a function of antenna height and size for three field measured wave fronts. The three fronts selected for the study were cases in which low angle radiation had introduced additional wave components at the receiver due to trapping or earth reflections. The field measured data were taken for a wavelength of 3.2 centimeters over a 27-mile path at the Naval Electronics Laboratories' desert site near Gila Bend, Ariz.

The field measurements were made with the phase difference equipment built by the Electrical Engineering Research Laboratory of The University of Texas for measuring the difference in phase at 3.2-cm wavelength between the fields of two antennas separated vertically by ten feet and the signal strength at each antenna.[3] The procedure for obtaining the data involved raising the receiver vertically, while holding the transmitter at a fixed level.

## II. Meteorological Considerations

The field measured data were taken such that each case analyzed represents a condition typical of a 24-hour meteorological cycle as observed at the desert site in Arizona.[4] Data for the 0021 curve, Fig. 1, were taken when a ground based duct was known to exist over the radio path. Data for the 0605 curve were taken when the duct was breaking up and meteorological conditions in general were irregular. Data for the 0857 curve were taken after the duct had disappeared and normal daytime conditions had set in. No attempt is made to correlate these meteorological observations with the indicated angle-of-arrival in this paper, except to note briefly the magnitude of the error in each case. This correlation is considered elsewhere.[1]

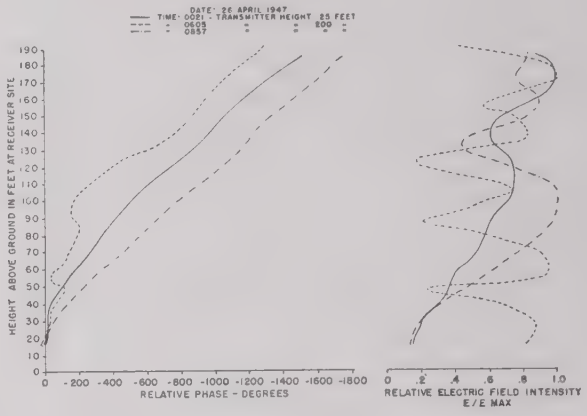


Fig. 1—Field measured phase-front and signal strength curves.

## III. Method of Determining the Indicated Angle-of-Arrival

The method used is that of vector addition. This method consists of summing up the signal strengths at the appropriate phase angles along the face of the antenna for various angles of antenna tilt. The resulting signal strength is plotted against angle of antenna tilt, and from the plot, the angle which gives the maximum signal is determined. This angle of tilt is the indicated angle-of-arrival.

This method necessarily assumes that each portion of the wave front can be regarded as a secondary source or Huygen's source of known electric intensity, phase, and polarization and that the receiving antenna has transmitting characteristics such that it generates a wave

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† Electrical Engineering Research Laboratory, The University of Texas, Austin, Texas.

[1] A. W. Straiton, W. E. Gordon, and A. H. LaGrone, "A method of determining angle-of-arrival," *Jour. Appl. Phys.*, vol. 19, pp. 524–533; June, 1948.

[2] E. W. Hamlin and W. E. Gordon, "Comparison of calculated and measured phase differences at 3.2 centimeters wavelength," Proc. I.R.E., vol. 36, pp. 1218–1223; October, 1948.

[3] F. E. Brooks, Jr., and C. W. Tolbert, "Equipment for measuring angle-of-arrival by the phase difference method," Electrical Engineering Research Laboratory, University of Texas, Report No. 2; May, 1946.

[4] J. R. Gerhardt, "Meteorological measurements in Arizona during March and April, 1946," Electrical Engineering Research Laboratory, University of Texas, *Report No. 5;* February, 1947.

that is uniform in phase and magnitude in the plane of the face. As a receiver, equal signals at any two points along its face produce equal response. This method is described by Friis and Lewis.[5] In general, an antenna with variations in response to equal signals along the face would indicate approximately the same angle-of-arrival as a somewhat smaller antenna of the characteristics assumed above.

The antenna itself is assumed to have a rectangular opening, to be vertically mounted, and to have a width so small that horizontal variations in phase and signal strength in the wave front are negligible.

## IV. Example of Method

Data: 0605 April 26, 1947. The data were taken from the phase front and signal strength curves in Fig. 1. A 100-foot antenna centered at 90 feet was assumed. The data consists of 50 signal strength magnitudes and relative time phase angles spaced evenly along the antenna face.

The solution is made by using the following equation:

$$E = \left[ \sum_{1}^{N} E_n \cos\left(\Phi_n - \frac{360\, l_n \sin\theta}{\lambda}\right) + j \sum_{1}^{N} E_n \sin\left(\Phi_n - \frac{360\, l_n \sin\theta}{\lambda}\right)\right] \frac{L}{N},$$

where,

$N$ = total number of field increments taken
$E_n$ = relative electric field intensity of increment $n$ $(E_n/E_{\max})$
$\phi_n$ = time phase of $E_n$ in degrees
$l_n$ = distance in feet from the electrical axis of the antenna to $E_n$ as measured along the antenna face
$\theta$ = antenna tilt angle. (For $\theta = 0°$, antenna face is vertical)
$\lambda$ = wavelength = 0.105 ft. (3.2 cm)
$L$ = vertical dimension of antenna face in feet
$E$ = relative antenna response.

The curves in Fig. 5 show a plot of relative antenna response $|E|$, versus angle of antenna tilt, $\theta$. The angle-of-arrival as indicated by maximum signal strength for the 100-foot antenna centered at 90 feet is $-0.050°$. This angle is shown plotted at 90 feet for the 100-foot antenna in Fig. 3.

## V. The Indicated Angle-of-Arrival from Analysis of the Field-Measured Phase Front

The indicated angle-of-arrival versus height as obtained from the field-measured phase fronts is shown in curve form in Figs. 2, 3, and 4 for several antenna sizes. On each curve in this series, the angle-of-arrival of a single ray, arbitrarily positioned, is shown for comparison. The single-ray curve, for a homogeneous atmosphere and a path length of 27 miles is a straight line with a slope of 0.0406° per hundred feet.

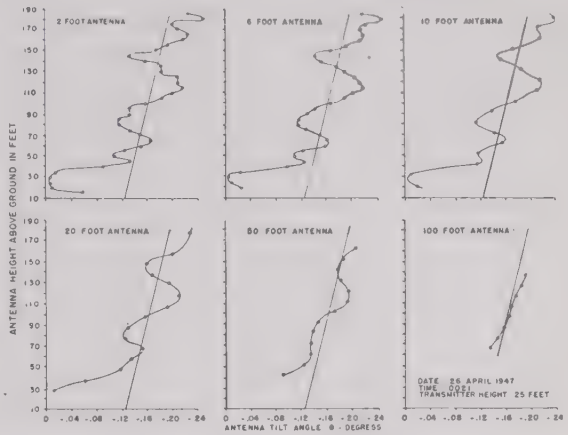


Fig. 2—Indicated angle-of-arrival at 0021.

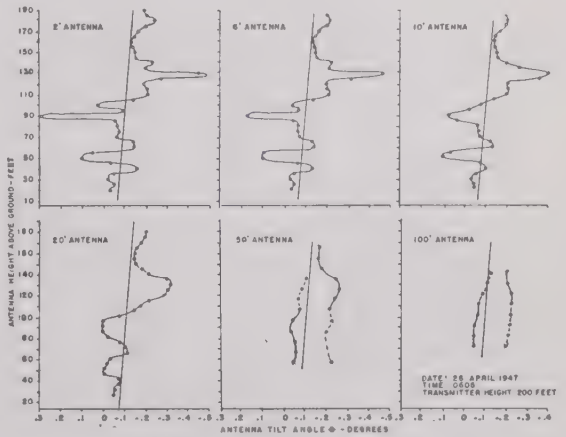


Fig. 3—Indicated angle-of-arrival at 0605.

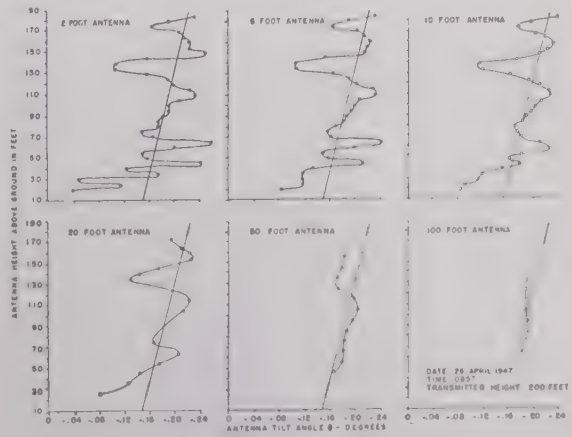


Fig. 4—Indicated angle-of-arrival at 0857.

[5] H. T. Friis and W. D. Lewis, "Radar antennas," *Bell Sys. Tech. Jour.*, vol. 26, p. 219; April, 1947.

A comparison of the field-measured and the single-ray indicated angle-of-arrival curves shows that the average slope of the field-measured curves agrees reasonably well with the slope of the single-ray curve, and that the field-measured curves fluctuate considerably with height. The fluctuation noted in the field measured indicated angle-of-arrival is evidence of the complexity of the wave front at the receiver.

In the field-measured cases, the greatest fluctuation in the indicated angle-of-arrival with height was observed in the two-foot antennas, and the least in the 100-foot antennas. This difference can be explained by the fact that the small antenna integrates over such a small portion of the wave front that any localized variation in phase has an important part in determining the tilt angle for maximum signal indication, and hence, the indicated angle-of-arrival. The large antenna, on the other hand, integrates over such a large portion of the wave front that localized variations are averaged out in the large signal received, and have little effect in determining the indicated angle-of-arrival.

Another point of interest in the field measured indicated angle-of-arrival is the sudden change in the angle observed in the 50-foot and 100-foot antenna curves in Fig. 3. (The indicated angle-of-arrival is shown by a solid line.) This phenomenon is not observed in any of the other antenna curves in this set nor in the sets shown in Figs. 2 and 4. This case is discussed in a later section.

## VI. Error in the Indicated Angle-of-Arrival

The error in the field measured indicated angle-of-arrival, relative to the angle-of-arrival of a single ray in a homogeneous atmosphere, can be obtained by comparing the field-measured curves with the single-ray curves in Figs. 2, 3, and 4.

The error is shown tabulated in Table I for the different antenna sizes. The meteorological conditions which existed at the time the field data were taken are also shown. The error is calculated by taking an average of the two greatest deviations in the indicated angle-of-arrival, one above and one below, from the angle-of-arrival of the single ray.

*Example:* Fig. 2, two-foot antenna:

Greatest deviation above (at 30 feet) $= \overline{\ } 0.125°$
Greatest deviation below (at 105 feet) $= 0.050°$
Error indicated $(0.125+0.050)1/2 = \pm 0.088°$.

TABLE I

ERROR IN THE INDICATED ANGLE-OF-ARRIVAL

| *Antenna Size L (Feet)* | *Fig. 2 Ground Based Duct* | *Fig. 3 Transitional Period* | *Fig. 4 Normal Daytime* |
|---|---|---|---|
| 2 | ±0.088° | ±0.382° | ±0.102° |
| 6 | ±0.088° | ±0.311° | ±0.084° |
| 10 | ±0.088° | ±0.234° | ±0.072° |
| 20 | ±0.085° | ±0.150° | ±0.052° |
| 50 | ±0.038° | ±0.107° | ±0.022° |
| 100 | ±0.013° | ±0.084° | ±0.012° |

## VII. Antenna Response for Various Angles of Tilt in Measured Fields

1. *One Hundred-Foot Antenna.* The series of curves in Fig. 5 show in detail the signal strength received versus angle of antenna tilt of a 100-foot antenna for the field-measured wave front taken at 0605. The tilt angle at which maximum signal occurs is taken to be the indicated angle-of-arrival and the points are plotted at the indicated height on the 100-foot antenna curve in Fig. 3.

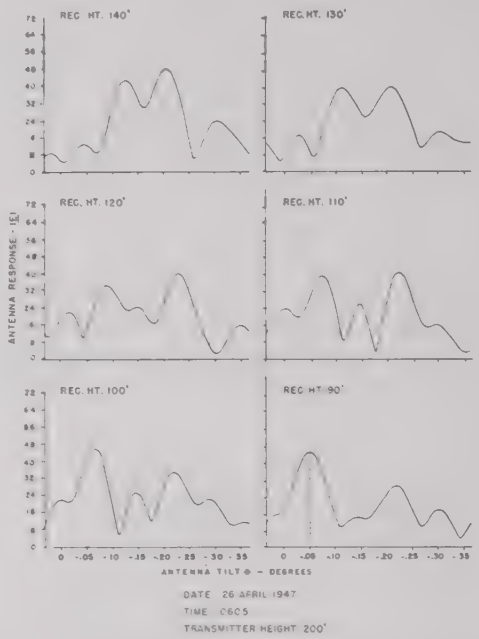


Fig. 5—One-hundred foot antenna patterns from field-measured phase front.

The curves in Fig. 5 show the interfering wave in the field-measured wave front which was suggested by the fluctuations in the indicated angle-of-arrival with height, Figs. 2, 3, and 4. The interfering wave appears as a strong second lobe in the antenna response pattern in this series of curves. In a similar study of the other two wave fronts, at 0021 and 0857, the interfering wave appeared relatively weak with respect to the main wave, yet strong enough to be identified as a second wave component and not as a minor lobe of the antenna response pattern.

The case shown by the curves in Fig. 5 is of particular interest because of the break observed in the angle at which maximum signal is received (solid line) in the 100-foot antenna curve in Fig. 3. A study of the curves in Fig. 5 shows the antenna maximum signal being determined by one wave components at the lower receiver levels and by another at the higher levels. This shift of the maximum signal from one wave component to the other is also observed to be abrupt, since both wave components are clearly defined at the height at which the change occurs. It should be noted that the plot in Fig. 3 includes the angle-of-arrival of each wave component for all antenna heights in this unusual case.

2. *Fifty-Foot Antenna.* The set of curves in Fig. 6 shows in detail the signal strength received versus angle of antenna tilt of a 50-foot antenna for the field-measured wave front taken at 0605. The tilt angle at which

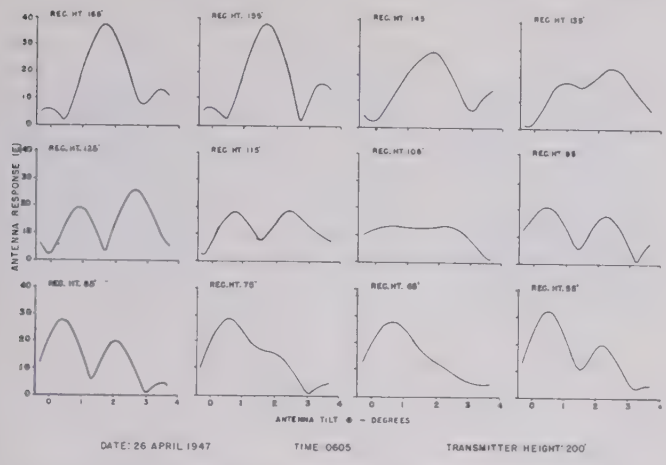


Fig. 6—Fifty-foot antenna patterns from field-measured phase front.

maximum signal occurs is taken to be the indicated angle-of-arrival and the points are plotted at the indicated receiver heights on the 50-foot antenna curve in Fig. 3.

As in the case of the 100-foot antenna analysis of this wave front, Fig. 5, these curves show two interfering waves of the same order of magnitude. The antenna maximum signal indication is again observed to shift from one wave component at the lower receiver levels to the other wave component at the higher receiver levels. The individual wave components are not as distinct at the point where the break occurs in this case as they were for the 100-foot antenna; however, the separate maxima are discernible.

The indicated angle-of-arrival curve for the 50-foot antenna in Fig. 3 includes the angle-of-arrival of both wave components for all antenna heights, where both were readable.

3. *Twenty-Foot Antenna and Smaller Antennas.* The small antennas which were used in the study of the wave fronts did not show a break in the indicated angle-of-arrival in the 0605 case as did the 50- and 100-foot antennas. A detailed study of the 20-foot antenna patterns did show evidence of the second wave component, but the antenna did not leave sufficient resolution to separate the components near the heights where their magnitudes were equal. The 10-, 6-, and 2-foot antenna patterns did not definitely show the second wave component.

4. *Discussion.* A study of the 0605 phase front curve, Fig. 1, for this unusual case suggests the possibility of two separate wave fronts, an upper and a lower, which merge at a height of about 100 to 110 feet. This is approximately the elevation at which the break in the indicated angle-of-arrival is observed in both the 50-foot and 100-foot antenna curves in Fig. 3. The two wave-front concept would also account for one signal being the stronger at elevations above 110 feet and the weaker below 100 feet.

## VIII. Antenna Response at Various Angles of Tilt for an Assumed Field

For comparison with the field-measured wave fronts, an assumed front made up of two plane waves, $\alpha$ and $\beta$, was analyzed. The method of analysis was by vector addition. The result of the analysis is shown in curve form in Fig. 7. In the analysis, $\alpha$ and $\beta$ were related as

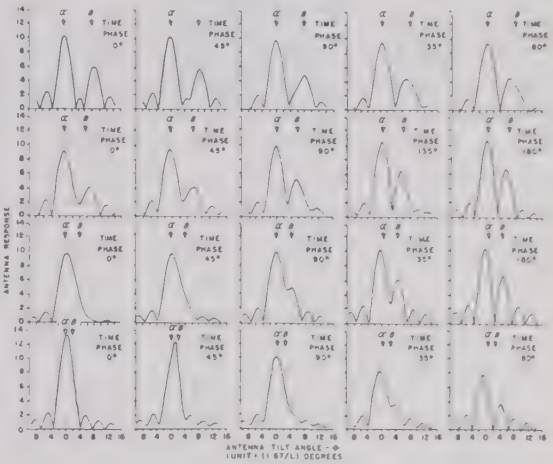


Fig. 7—Antenna response for phase front composed of two plane waves.

follows: the $\alpha$ wave was assumed to have a magnitude of 1.0 and to always arrive horizontally, i.e., at $\theta = 0°$. The $\beta$ wave was assumed to be one-half the magnitude of $\alpha$ and to arrive at some angle below horizontal (negative $\theta$) as indicated by the position of the $\beta$ arrow. The relative time phase of $\alpha$ and $\beta$ was assumed as indicated on each curve. The antenna tilt scale is calibrated in terms of antenna size $L$, where $L$ is the vertical dimension in feet; hence, the curves are not restricted to a given size antenna.

A study of the curves in Fig. 7 shows graphically that complex response patterns such as those in Figs. 5 and 6 can be obtained from two plane waves, and indicates the factors which determine the pattern. The effect of these factors on the indicated angle-of-arrival is also clearly shown. The controlling factors are found to be the relative time phase and the angular separation of the two wave components. Other factors, which would affect the indicated angle-of-arrival, but which were not shown directly by the analysis, would be the relative magnitude of the wave components and the introduction of further components.

## IX. Comparison of the Theoretical Wave-Front Curves with the Field-Measured Wave-Front Curves

A comparison of the curves in Fig. 7 with those obtained from the field-measured wave fronts reveals a

remarkable amount of similarity in some of the curves, and a few cases where the curves are almost identical. This fact strongly suggests that the wave components of the measured field were those of the assumed field. If this is true, then a field-measured wave front which yields a curve that agrees identically with a curve from an assumed wave front, will have wave components of the same relative magnitude, time phase, and angular separation as those of the assumed front. In this manner, wave components in a field-measured wave front could be separated.

### X. Conclusions

1. For the field-measured data, antennas under 10 feet in size were found to be small enough to follow the localized height variation in phase; thus, the phase difference method (footnote reference (3)) agrees with the vector addition method in determining the indicated angle-of-arrival for these antennas.

2. The large antennas were found to be relatively insensitive to the localized phase variation, but were considerably affected by the major phase variations noted. For these larger antennas the phase difference method does not give the tilt angle which results in maximum signal and the vector addition method is necessary.

3. The effect of antenna size and height above ground on the angle-of-arrival as indicated by pointing for maximum signal is shown in curve form in Figs. 2, 3, and 4 and in Table I for three measured fields. The inaccuracies of this method of finding the angle-of-arrival of a radio wave are generally well known; however, this study, in addition to calculating the magnitude of some of these errors, shows how the error fluctuates with antenna size and height above ground.

4. Comparing the antenna signal strength response curves for field-measured data with similar curves obtained by analysis of an assumed wave front offers a possible means of separating the wave components in the field-measured wave front.

# Design of Tunable Resonant Cavities With Constant Bandwidth*

L. D. SMULLIN†, ASSOCIATE, IRE

A PROBLEM of some interest in microwave circuit design is that of making a tunable filter whose loaded $Q$, or whose frequency bandwidth is constant over the tuning range. It is well known that a cavity using inductive irises as the coupling elements has a rapidly varying $Q_L$ and that the bandwidth may change by almost a factor of 2 when the cavity is tuned over a 10 per cent range. It can be shown, however, that the use of capacitive irises results in a reasonably constant bandwidth.

If one computes the way in which the coupling susceptance should vary with frequency in order to make a cavity with constant loaded $Q$ ($Q_L$) or constant bandwidth, one obtains the curves shown in Fig. 1. (The loading due to cavity losses has been neglected, which is reasonable for values of $Q_L \simeq 100-300$.) Here we have the abscissa proportional to $\lambda/\lambda_c$ where $\lambda$ is the free-space wavelength of the applied signal, and $\lambda_c$ is the cut of wavelength of the wave guide. Obviously, a given value of loaded $Q$ can be obtained by the use of either an inductive or a capacitive coupling iris, and these two branches are shown in Fig. 1. Also plotted in Fig. 1 are the curves showing the frequency dependence of waveguide inductive and capacitive irises. It is clear that a capacitive iris has a frequency dependence that will be in between that required for constant $Q_L$ and constant bandwidth. The inductive iris, however, has a frequency characteristic of just the opposite slope from that required for constant $Q_L$ or bandwidth.

Capacitive irises have the disadvantage that one can only get values of about $B/Y_0 \leqq 10$ without going to very minute openings. Thus it does not appear possible to make cavities with $Q_L$ greater than about 300 by this method.

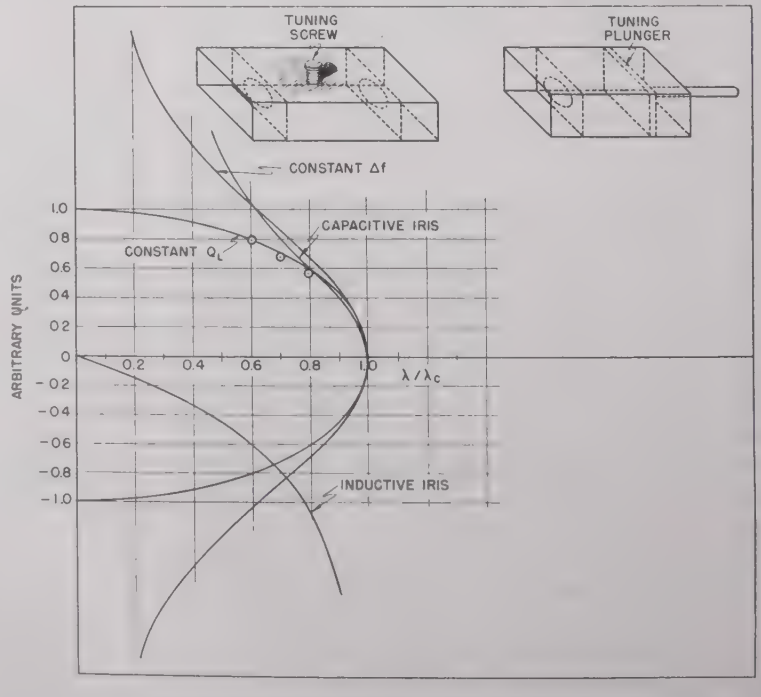


Fig. 1—Frequency dependence of coupling susceptance necessary to give constant $Q_L$ or constant $\Delta f$.

* Decimal classification: R119. Original manuscript received by the Institute, June 13, 1949; abstract received, August 30, 1949. This work has been supported in part by the Signal Corps, the Air Materiel Command, and O.N.R., and is abstracted from Research Laboratory of Electronics Technical Report No. 106, April 5, 1949.

† Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Mass.

# Contributors to the Proceedings of the I.R.E.

R. H. Dishington was born on March 21, 1919, in Green Bay, Wis. He received the B.E.E.E. degree from the University of Southern California in 1942, and at that time entered the test course of the General Electric Co. Early in 1943 he did radio research for Bendix Aviation, Ltd., and taught night classes in electronics at the University of Southern California. In June of that year Mr. Dishington became a lecturer in electrical engineering at that University. Since the fall of 1947, he has been engaged in research work with The Rand Corp., Santa Monica, Calif.

R. H. Dishington

Mr. Dishington is an associate member of AIEE. He served on the electronics committee of the Los Angeles Section in 1943–1944. He is also a member of Eta Kappa Nu.

❖

Rudolf Kompfner was born in Vienna, Austria, on May 16, 1909. He attended the Realschule and Technische Hochschule in Vienna, and was graduated from the faculty of architecture in 1933. In 1934 he came to England to continue his study in architecture privately, and became the director of a building firm in 1937. Throughout these years, he devoted much of his spare time to television, radio, and physics.

Rudolf Kompfner

Mr. Kompfner entered the Admiralty service in 1941 as temporary experimental officer, taking up duty first in the physics department at Birmingham University. Since 1944 he has been associated with the Clarendon Laboratory at Oxford University, England.

❖

For a photograph and biography of W. W. Harman, see page 1435 of the November, 1949, issue of the Proceedings of the I.R.E.

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For a photograph and biography of Frederick W. Schott, see page 780 of the July, 1949, issue of the Proceedings of the I.R.E.

A. H. LaGrone (M'48) was born in Pauola County, Texas, on September 25, 1912. He received the degree of B.S. in electrical engineering from the University of Texas in 1938. After four years as distribution engineer with the San Antonio Public Service Co., San Antonio, Texas, he was commissioned in the U. S. Naval Reserve, and was ordered to active duty with the Navy in June, 1942. While in the Navy, Mr. LaGrone was instructor in radar at the Massachusetts Institute of Technology and later Radar Officer aboard the U.S.S. *Gillette*, D. E. 681, in the Atlantic.

A. H. LaGrone

At the conclusion of the war, Mr. LaGrone, then a lieutenant commander, was ordered to inactive duty and accepted the position of radio engineer with the Electrical Engineering Research Laboratory, the University of Texas. Mr. LaGrone also attended the University of Texas and was awarded the degree of M.S. in electrical engineering in 1948.

Mr. LaGrone is a member of Eta Kappa Nu and Tau Beta Pi.

❖

Keith MacDonald was born in Glasgow, Scotland, on July 24, 1920. He received the M.A. degree in mathematics and natural philosophy in 1941 and the Ph. D. degree in 1946, both from Edinburgh University. He served in the army as a radar and telecommunications officer from 1941 to 1946.

Keith MacDonald

Since 1946, Dr. MacDonald has been a research fellow in physics, Clarendon Laboratory, Oxford, England, working chiefly on properties of metals at very low temperatures, at the same time maintaining his interest in noise problems and fluctuations analysis.

❖

For a photograph and biography of K. Tomiyasu, see page 1156 of the October, 1949, issue of the Proceedings of the I.R.E.

Leslie A. Moxon was born on March 15, 1909. He received the London University B.Sc. degree in electrical engineering in 1929, following a 3-year course at the City and Guilds Engineering College. For the next two years he carried out research on high-frequency ammeters under the auspices of the Department of Scientific and Industrial Research, afterwards joining the staff of Murphy Radio Ltd., where he was responsible for the development of broadcast receivers and research on associated problems until 1940.

Leslie A. Moxon

In 1941 he joined H. M. Signal School in Portsmouth, England, where he took charge of a section concerned with the development of radar receivers, and he is now a member of the Royal Naval Scientific Service.

Mr. Moxon is the author of various technical papers, and of a book entitled, "Recent Advances in Radio Receivers," recently published by the University Press, Cambridge, England. He is an Associated Member of the British Institution of Electrical Engineers.

❖

Leo Storch was born on March 3, 1921, in Vienna, Austria. In January, 1944, he received the B.S.E.E. degree cum laude from the School of Technology, College of the City of New York. He was awarded the M.A. degree by the Graduate School of Stevens Institute of Technology in June, 1947.

Leo Storch

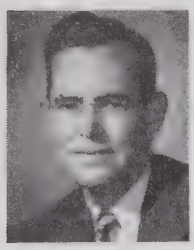
From February, 1944, to July, 1947, Mr. Storch was an assistant engineer in the Test Set Design and Development Department of the Western Electric Co. in Kearny, engaged in the circuit design for a wide variety of measuring equipment.

From August, 1947, to June 1948, he was associated in the capacity of engineer with the Teleregister Laboratories in New York, N. Y., where he was active in various phases of an electronic computer development project.

Since June, 1948, Mr. Storch has been a member of the advanced development group in the aviation radio section of RCA Victor in Camden, N. J. He has been principally concerned with the design of antenna tuning and loading networks for wide-band aircraft communications transmitters.

# Contributors to the Proceedings of the I.R.E.

A. W. Straiton (M'47) was born in Tarrant County, Tex., on August 27, 1907. He received the B.S. degree in electrical engineering in 1929, the M.A., in 1931, and the Ph.D. in 1939, all from The University of Texas.

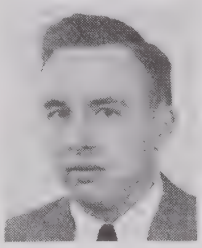


A. W. Straiton

Dr. Straiton spent one year at Bell Telephone Laboratories, after which he taught at Texas College of Arts of Industries as assistant professor, associate professor, and professor of electrical engineering, successively. From 1941 to 1943, he was head of the Department of Engineering, Institutional Representative of E.S.M.W.T., and director of the Pre-Radar Training courses. Since 1943, he has been associate professor of electrical engineering at The University of Texas. He was recently made director of the Electrical Engineering Research Laboratory.

Dr. Straiton is a member of Sigma Xi, Tau Beta Pi, Eta Kappa Nu, the American Institute of Electrical Engineers, and the American Society for Engineering Education.

James H. Tillotson (S'45) was born in Oak Park, Ill., on November 14, 1923. He received the B.S. degree in electrical engineering from Purdue University in 1945, and the M.S. degree in 1947 from the same institution. Since 1947, he has been a graduate student at Stanford University, employed as a research assistant in the Electronics Research Laboratory, and also in the Microwave Laboratory at the University.



J. H. Tillotson

Mr. Tillotson is a member of Sigma Xi, Tau Beta Pi, and Eta Kappa Nu.

❖

For a photograph of Karl R. Spangenberg, see page 780 of the July, 1949, issue of the Proceedings of the I.R.E.

D. L. Waidelich (S'37–A'39–SM'44) was born on May 3, 1915, at Allentown, Pa. He received the B.S. degree in electrical engineering in 1936, the M.S. degree in 1938, both from Lehigh University, and the Ph.D. degree from Iowa State College in 1946. He was a teaching assistant at Lehigh University from 1936 to 1938, and since 1938 has been a professor of electrical engineering at the University of Missouri.

D. L. Waidelich

During 1944 and 1945, Dr. Waidelich was with the U. S. Naval Ordnance Laboratory in Washington, D. C., as an electrical engineer. For various summers he has also worked with the Bell Telephone Laboratories, New York, N. Y., the Westinghouse Electric Corporation at Bloomfield, N. J., and the U. S. Naval Electronics Laboratory at San Diego, Calif., as a consulting engineer. In 1946 he received mention by Eta Kappa Nu as one of the outstanding young electrical engineers in America. He is a member of the American Institute of Electrical Engineers, the American Society for Engineering Education, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu.

# Correspondence

## Chemical Composition and Structure of the Atmosphere*

Several year ago while investigating various atmospheric conditions and their effects upon high-speed racing engines while burning high-performance low-mileage alcohol blends, we ran across some interesting data upon the chemical composition and structure of the atmosphere. For one thing, there appears to be a gravitational stratification of the air, with a gradual change in chemical composition with altitude, until finally little more than the light hydrogen and helium remain at 1,000 to 2,000 miles.

Another interesting fact seems to be that many trace gases are contained in the air in appreciable percentages (ammonia, hydrogen, carbon dioxide, nitric oxides, etc.) other than water vapor and the inert gases. These vary in their concentration with locality, altitude, and time. We often wondered how much this condition has effected radio-wave propagation. Various papers on this subject do not appear to take the above factors into consideration.

Turning to the field of astronomy, the gravitational stratification of the terrestial atmosphere can be carried out still further. Recent theories of an "exploding universe" appear less credulous on the assumption that starlight spectroscopic frequency shifts are due largely to tenuous dust and gas clouds in interstellar space. Hence it might be reasoned that the earth's stratosphere does not end abruptly at several hundred miles, but gradually thins out into the highly rarefied gas and dust-filled space between the planets and the parent sun. The earth may also be ringed by faint dust rings similar to the prominent rings of Saturn, and the sun may be exploding columns of gases into space. These may account for some of the peculiar long-time-interval echoes and doppler shifts noted in radio-wave propagation studies. Jansky apparently suspected some such effects a good many years ago.

Ted Powell
5719 69th Lane
Maspeth, L. I., N. Y.

* Received by the Institute, August 8, 1949.

# Correspondence

## Simplified Frequency Stabilization*

Previous attention to the problem of frequency stabilization of a reflex klystron has emphasized maximum stability rather than simplicity of operation and ease of AM. There is a large class of instrumentation problems in microwaves that does not require the maximum obtainable stability and does depend on AM. Hence there may be some general interest in one design of a compromise stabilizer that has proven itself in laboratory use.

Fig. 1 is a block schematic of a unit which is simple in operation and whose output is square-wave amplitude-modulated. Approximately 1 per cent of the power delivered by a klystron (such as a 2K39) is diverted by a directional coupler to a frequency discriminator composed of an unmatched hybrid junction, a phase changer, and a resonant cavity. The phase changer is adjusted to deliver equal modulated power to the detectors terminating the *E*- and *H*-arms of the hybrid when the cavity is detuned from resonance and the *AFC* switch is set to "off." The cavity is then tuned to resonance which again equalizes the power in the *E*- and *H*-arms, and the *AFC* switch is turned to "on." Subsequently, any tendency toward frequency change will cause an increase in power in one arm and a decrease in power in the other arm as a function of the cavity phase characteristic near resonance. Since there is a 180° phase reversal in the reflection from the cavity at resonance, the direction of frequency drift will determine whether the *H*-arm increases and the *E*-arm decreases or vice versa. Hence the amplified and rectified detector components may be used to control the $g_m$ of the modulator tube and, consequently, the amplitude of the square-wave output. When this square wave is added to the steady-state klystron reflector voltage by derivative coupling, the total reflector voltage at the "on" oscillating condition is controlled by the discriminator and, consequently, the frequency of oscillation is stabilized.

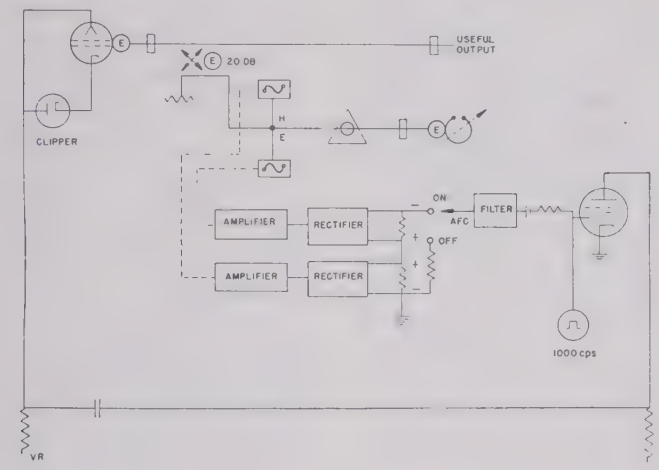



Fig. 1

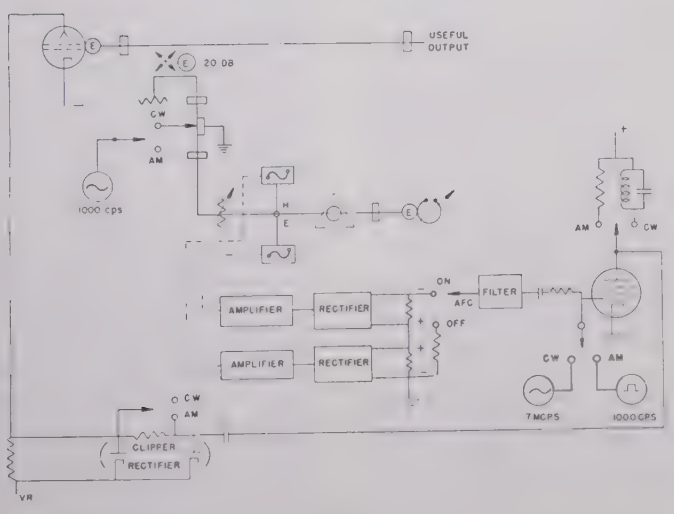



Fig. 2

With a slight modification, this stabilization scheme can be made to operate either with CW or with AM output (see Fig. 2). In this case the sampled power diverted to the discriminator is sinusoidally modulated by a crystal, amplified, rectified, and used to control the $g_m$ of the modulator tube as before. However, for this case, a 7 Mc sine wave is derivatively coupled to a rectifier and the controlled direct current output is added to the steady-state reflector voltage. Conversion from AM to CW operation is accomplished by a single gang switch.

Stabilization of the order of 1 part in $10^5$ is obtained for either the AM or CW case. The ease of operation in comparison to usual methods is, of course, the outstanding feature. Unskilled personnel are consistently able to "lock on" an arbitrary frequency in about 15 seconds after the klystron has been set.

Owen A. Tyson
Antenna Research Branch
Naval Research Laboratory
Washington 25, D. C.

* Received by the Institute, July 20, 1949.

## Patent References in Technical Papers*

It has become impressed upon me more and more through the past forty years, that papers published in the Proceedings of the I.R.E., and most other technical and scientific bodies, include very scant references to patents, either in footnotes or in appended bibliographies.

Patents constitute one of the largest, most comprehensive, and very frequently, the *only* source of technical information on many subjects, yet references to them by technical writers seem to be, for the most part, studiously avoided. This is true also of technical reference books.

Would it not be a very useful service if this were brought to the attention of our technical authors?

B. F. Miessner
Van Beuren Rd.,
RFD #2, Morristown,
N. J.

* Received by the Institute, August 15, 1949.

# Correspondence

## Resistance Attenuating Networks*

The equations for the components of a resistance attenuating network in terms of hyperbolic functions are well known. The derivation given below is of interest because of its simplicity, and because it leads to a novel form for the equations.

Consider first the $T$ network of Fig. 1, where the series arms are each equal to $R_0$ and the shunt arm is a short circuit. This

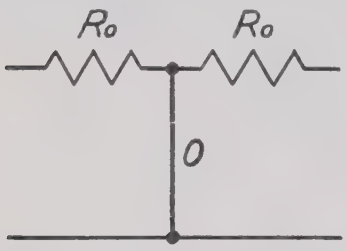



Fig. 1—Prototype resistance attenuating pad.

network obviously has a characteristic impedance equal to $R_0$ and infinite attenuation. Now consider the general "$m$" derived section, shown in Fig. 2, obtained from the

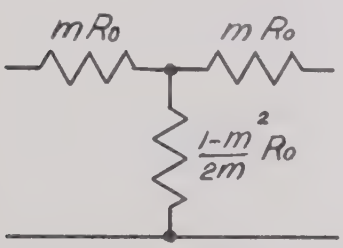



Fig. 2—"$m$" derived resistance attenuating pad loss $= 20 \log \left(\frac{1+m}{1-m}\right)$ db.

network of Fig. 1. This section has the same characteristic impedance ($R_0$) for all values of $m$ (but only for $0 < m < 1$ will the network be realizable). It is readily shown that if the network of Fig. 2 is fed from a generator of impedance $R_0$ and terminated in a like impedance that the ratio of load current to generator current is

$$\frac{I_L}{I_G} = \frac{1-m}{1+m}.$$

Thus the loss of the network is

$$\text{loss} = 20 \log \left(\frac{1+m}{1-m}\right) \text{decibels.}$$

SIDNEY BERTRAM
Ohio State University
Columbus, Ohio

* Received by the Institute, August 24, 1949.

## Ground-Wave Field-Strength Calculation*

With regard to the paper by H. L. Kirke of the B.B.C. in your May, 1949,[1] issue, I should like to draw your attention to the fact that the recovery effect predicted in my paper[2] to which he refers has been substantiated by an experiment on a wavelength of 4m.[3] We have just completed a further test on 100 m. across a land/sea boundary also agreeing with the predicted result, and it is hoped to publish an account of these two experiments as part of another paper in the *P.I.E.E* later in the year.[4]

My purpose in writing is to say that although my method is empirical in the neighborhood of a boundary, these experiments suggest that it is in fact a close approximation to the truth in this important region, where the other methods described by Mr. Kirke are definitely inadequate.

The experiments analyzed in his paper certainly imply that where the conductivity changes are complex, one method or another under the conditions assumed may happen to fit the measured values best, and that the Somerville method, which has the merit of simplicity, is adequate in many cases. As Mr. Kirke admits, however, it is purely empirical, having no other theoretical basis than that it is "a move in the right direction" from the P. P. Eckersley method, so that it obeys the reciprocity condition only approximately and not of necessity.

My own method is admittedly in effect the P. P. Eckersley method made reciprocal, but I have given considerable theoretical justification for it well away from the boundary, more particularly at the short-wave limit. Mr. Kirke points out that, as opposed to the other methods, it can even give an increase in field-strength on crossing a boundary from low to high conductivity. This is something of an understatement, for the increase can be spectacular, as is shown by the experiments referred to above, and can be of profound practical importance, as our further paper will reveal.

I feel, therefore, that in adopting any particular method in the absence of a complete mathematical solution of the problem, its possible limitations should be clearly realized, especially in the neighborhood of a boundary, and where the reciprocity condition is concerned. The recovery effect can now be regarded as a well-established propagation phenomenon, and one which must be taken into account in problems of ground-wave coverage over a composite path.

Theoretically, with horizontal polarization the effect should be reversed, but it would be confined close to the surface, and so it would be difficult to detect and of little practical significance.

G. MILLINGTON
Marconi's Wireless Telegraph Co. Ltd.
Baddow Research Lab.
Chelmsford, Essex, England

* Received by the Institute, May 23, 1949.

[1] H. L. Kirke, "Calculation of ground-wave field-strength over a composite land and sea path," PROC. I.R.E., vol. 37, pp. 489–497; May, 1949.
[2] G. Millington, "Ground-wave propagation over an inhomogeneous smooth earth," *Proc. I.E.E.*, vol. 96, Part III, no. 39, pp. 53–64; 1949.
[3] G. Millington "Ground-wave propagation across a land/sea boundary," *Nature*, vol. 163, p. 128; 1949.
[4] G. Millington, "Ground-wave propagation across a land/sea boundary 100 m," *Nature*, vol. 164, p. 114; 1949.

## Kirke's Reply*

Mr. Millington, in his letter to the Editor, mentions that he has carried out experiments on wavelengths of 100 m. and 4 m. I have seen the results of these experiments, which show a very marked recovery effect on passing from land to sea. The experiments were carried out under more extreme conditions than were possible in the experiments mentioned in my paper, and also show that under certain conditions it is better to site a transmitter farther away from the service area if by doing so the initial path can be over sea.

While, as pointed out in my paper, the Somerville method gives better correspondence with practical results than the Eckersley method, there is no doubt that it does not give an adequate allowance for the recovery effect on passing from land to sea, nor does it give a sharp enough drop when passing from sea to land.

As pointed out in Mr. Millington's letter, while the Somerville method is adequate in many cases and has the merit of simplicity, it would be unwise to place complete reliance on that method in all cases.

Although the Somerville method is rapid in use, the additional labor involved in the use of the Millington method is not great, and even if the Somerville method is used it would be wise to carry out a few check calculations using the Millington method, particularly in the neighborhood of a boundary.

The results of Mr. Millington's experiments when published will be of considerable interest.

H. L. KIRKE
British Broadcasting Corp.
London, W. 1,
England

* Received by the Institute, July 18, 1949.

# Correspondence

## Note on Transit-Time Deterioration*

It is the aim of this note to give a simple derivation and a generalization of some formulas which were published recently.

We start with transit time deterioration of the density modulation of an electron beam due to the velocity distribution of the electrons.[1] Let $I$ be the dc beam current and $i_0 \exp(j\omega t)$ the ac convection current at the beginning of the beam. Let $p(V)\,dV$ be the probability of an electron velocity between $V$ and $(V+dV)$ volts in the beam. Then the convection current $i(t)$ at the instant $t$ at a distance $d$ from the beginning of the beam is:

$$i(t) = \int_0^\infty i_0 \exp\{j\omega(t-\tau)\}\,p(V)dV = i_0 \exp(j\omega t) f(\omega), \quad (1)$$

if it is observed that the electrons having a velocity between $V$ and $(V+dV)$ and arriving at this point at the instant $t$ started at a time $(t-\tau)$, where $\tau$ is the transit time of the electrons along the distance $d$ and:

$$f(\omega) = \int_0^\infty \exp(-j\omega\tau)\,p(V)dV. \quad (1a)$$

We apply this result to an investigation of transit time deterioration of the space-charge reduction of shot effect in electron beams.[2] Consider an electron beam satisfying the conditions:

1. Saturated shot noise in the beam current.
2. No correlation between the fluctuations in electron velocity and in electron density at the beginning of the beam.
3. The velocities of the individual electrons are completely random.

After conditions 1 and 3, the arrival of an electron at any point of the beam is an independent event occurring at random, so that we have for the total noise current at any part of the beam:

$$\overline{i_0^2} = 2eI\Delta\nu. \quad (2)$$

Traveling along the beam, the initial density fluctuations decrease due to the velocity distribution, but on the other hand the initial velocity fluctuations are transformed into density fluctuations, such that (2) remains valid. Let the first effect give a contribution $i_1$ and the second one a contribution $i_2$ to the total noise current $i_0$. After condition 2 these contributions are uncorrelated and have to be added quadratically, so that:

$$\overline{i_0^2} = \overline{i_1^2} + \overline{i_2^2}. \quad (3)$$

As $\overline{i_1^2}$ follows from (1) we have:

$$\overline{i_2^2} = 2eI\Delta\nu[1 - |f(\omega)|^2]. \quad (4)$$

Condition (4) was derived under the three conditions mentioned previously. But obviously $i_2^2$ only depends upon the *magnitude* of the velocity fluctuations, so that (4) remains valid even if conditions 1 and 2 are no longer satisfied. $\overline{i_2^2}$ gives the correct expression for the transformation of velocity fluctuations into density fluctuations along the beam, as long as condition 3 is satisfied, even though it may happen that $i_1$ and $i_2$ are correlated and cannot be added quadratically, if conditions 1 and 2 do not hold.

We now apply this result to the case of a "shifted" Maxwellian velocity distribution discussed by several authors[2,3]: $p(V)\cdot dV = 0$ for $V < V_0$; $p(V)dV = \exp(-\Delta V/V_T)\,d(\Delta V/V_T)$ for $V \geq V_0$ in which $T$ is the cathode temperature, $\Delta V = (V - V_0)$ and $V_T = kT/e = T/11{,}600$ volts.

Let $\tau_0$ be the electron transit time along the distance $d$ for those electrons having an initial velocity $V_0$, then the transit time $\tau$ for the electrons having an initial velocity $(V_0+\Delta V)$ is:

$$\tau = \tau_0[V_0/(V_0+\Delta V)]^{1/2} = \tau_0 - \tfrac{1}{2}\tau_0(\Delta V/V_0), \quad (5)$$

if $(\Delta V/V_0) \ll 1$. Introducing this result into (1a) we obtain:

$$f(\omega) = \exp(-j\omega\tau_0)\,\frac{2V_0/V_T}{2V_0/V_T - j\omega\tau_0}. \quad (6)$$

Substituting this into (1) we obtain:

$$i(t) = i_0 \exp\{j\omega(t-\tau_0)\}\,\frac{2V_0/V_T}{2V_0/V_T - j\omega\tau_0}, \quad (7)$$

equivalent to a result derived previously by Barlow.[3]

Substituting (7) into (4) we obtain:

$$\overline{i_2^2} = 2eI\Delta\nu\,\frac{(\omega\tau_0)^2}{(2V_0/V_T)^2 + \omega^2\tau_0^2},$$

a formula which was recently obtained by MacDonald.[3]

A. van der Ziel
University of British Columbia
Vancouver, B. C.
Canada

* Received by the Institute, September 2, 1949.

[1] M. J. O. Strutt and A. van der Ziel, "Application of velocity modulation tubes for reception at unf and shf," PROC. I.R.E., vol. 36, pp. 19–23; January, 1948.

[2] D. K. C. MacDonald, "Transit time deterioration of space-charge reduction of shot effect," *Phil. Mag.*, ser. 7, vol. 40, pp. 561–568; May, 1949.

[3] M. J. O. Strutt and A. van der Ziel, Discussion on: "Application of velocity modulation tubes for reception at unf and snf," PROC. I.R.E., vol. 37, pp. 896–900; August, 1949.

## Field-Strength Observations Made During the Total Eclipse of the Sun*

During the total eclipse of the sun which occurred on November 1, 1948, the following observations were made at Eastleigh Aerodrome, Nairobi, Kenya Colony, regarding the propagation of electromagnetic waves. It is thought that they may be of interest in view of the fact that this station was within the path of totality.

Observations were made on an army communications receiver Type R 206, Mark II, using a short, vertical antenna of small effective height; this equipment is in daily use in the electronics section of the East African Meteorological Department, at Eastleigh Aerodrome.

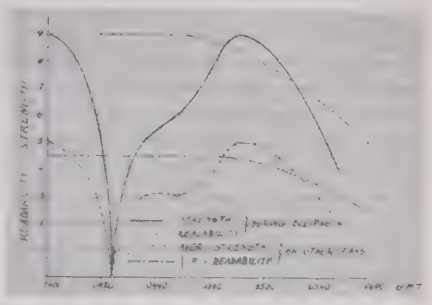


Fig. 1

The electronics section had planned to release additional radio sondes for the purpose of sounding the atmosphere during the three days centered round the eclipse. Two days before the eclipse, it occurred to the writer that it would be interesting to observe the changes in field strength of a short-wave station whose line of propagation or some part of it would roughly coincide with the path of the total eclipse. The choice fell on the station WWV in Washington, D. C., broadcasting on 15 Mc because it seemed likely that, at the time of the eclipse (0424 G.M.T.), its transmissions would be received along a great-circle path via S.E. Australia and the Pacific ocean; i.e. approximately the same line as that of the eclipse. Unfortunately, it was not possible in so short a time to install a directional antenna. The receiver is not equipped with a field-strength indicator and the writer had to rely on his experience in judging strength of reception and readability.

The observations made are plotted in Fig. 1 and show distinctly the change in reception conditions. It will be seen that the reception of WWV disappeared completely during the period of the total eclipse, and reverted to normal by the time that the sun was completely unobscured. Field-strength observations (mean values) for the day preceding and the day following are also shown and it can be stated that these are quite typical.

It is realized that the observations described above were made without adequate preparation and, consequently, the results should be treated with extreme reserve. It is felt, however, that such a clearly defined change in reception conditions corresponding with the eclipse of the sun were worthy of report and that, on future occasions, it would be worth organizing a properly prepared series of observations.

The report is published by kind permission of the acting director of the East African Meteorological Department.

J. Gross
P.O. Box 973
Nairobi, Kenya Colony

* Received by the Institute, July 12, 1949.

# Institute News and Radio Notes

## Technical Committee Notes

Approval of the formation of a technical committee on Instruments and Measurements by the Board of Directors was announced at a September session of the **Standards Committee on Instruments and Measurements.** Serving as Chairman is Professor Ernst Weber of the Polytechnic Institute of Brooklyn. Millard A. Baldwin, Jr., of the Bell Telephone Laboratories, Murray Hill, N. J., was appointed Television Co-ordinator by the Standards Committee. He will be chairman of a small subcommittee for the co-ordination work within the IRE and with other organizations in order to expedite production of urgently needed standards on television and video techniques. Approval was granted for the *Standards on Reference Designations* (for the identification of electrical, electronic and mechanical parts and their associated graphical symbols) prepared by the **Symbols Committee.** . . . The **Electron Tubes and Solid-State Devices Committee,** at a meeting September 16, reported that it will complete definitions for publication in the February issue of PROCEEDINGS. . . . The **Electronic Computers Committee** met on September 14 at the Computational Laboratory of Harvard University with Jay W. Forrester, Chairman, presiding. At present the Committee is concerned chiefly with the formulation of the Committee's scope and subcommittee structure to give equitable coverage to analog and digital computers, with the compilation of a comprehensive computer bibliography, with the preparation of a dictionary of standard computer definitions, and with methods of interchange and dissemination of information on electronic computers. . . . L. C. Van Atta presided at the September 12 session of the **Antennas and Wave Guides Committee.** A. G. Fox, Chairman of the **Subcommittee on Wave Guides,** reported that his group had formulated several recommendations for presentation to the Committee. The definitions were adopted by the main committee. Other terms will be submitted to the attention of the **Wave Propagation Committee and the Circuits Committee** for definition. . . . The **Joint Technical Advisory Committee,** at an all-day session September 22, was concerned principally with the presentation of the JTAC's report to the FCC at the September hearing on Allocations for Television Broadcast Services. Donald G. Fink, Chairman, presented JTAC's testimony at the hearing.

## National Bureau of Standards Publishes Electrical Measure

"Establishment and Maintenance of the Electrical Units" is the title of a new booklet published by the National Bureau of Standards and available from the U. S. Government Printing Office. It describes the system of electrical measurement using "absolute" units, adopted by the International Conference of Weights and Measures, officially instituted January 1.

## Standards Notice

This issue of the PROCEEDINGS contains the following standards: **Standards on Piezoelectric Crystals, 1949; Standards on Radio Aids to Navigation, Definition of Terms, 1949; Standards on Railroad and Vehicular Communications; Methods of Testing, 1949; Standards on Tests for Effects of Mistuning and Downward Modulation, 1949.**

It is the aim of the Board of Directors to include the standards in the PROCEEDINGS unless unforeseen contingencies arise so as to make them available to all members. All issues of the PROCEEDINGS containing such standards will carry a mention of that fact on their front covers in red, and will be indicated by a red band on the spine of such issues. Reprints of such standards, while available, may be purchased from IRE headquarters.

A list of available standards and their prices may be found on the back page of the Annual Index facing page 33a in this issue.

## IRE Announces Inception of Antennas, Propagation Group

An IRE Professional Group on Antennas and Propagation has been formed with membership to include those having professional interest in antennas and propagation (including waveguides). IRE members who wish to enroll may do so by forwarding a card to the Membership Committee, Professional Group on Antennas and Propagation, The Institute of Radio Engineers, 1 East 79 Street, New York 21, N. Y.

The group held a three-day meeting in conjunction with the URSI in Washington, D. C., beginning October 31. A West Coast meeting is planned for next Spring.

## Crystal Oscillator Plates Used for High Frequencies

Crystal grinding methods and machinery have been investigated by the National Bureau of Standards in order to overcome difficulties in supplying very thin quartz crystal oscillator plates having fundamental frequencies up to 100 Mc or even higher. Improved equipment, capable of producing 0.001-inch thick quartz crystals with a high degree of parallelism and flatness, can be used for grinding equally thin wafers from a variety of other materials. The Bureau has found that a promising application is the production of extremely thin dielectric plates for miniature radio condensers.

## Members Are Appointed To Research, Development Board

Army, Navy, and Air Force representatives who will serve on the Research and Development Board, Department of Defense, have been announced by the Secretaries of the three Departments. They have been chosen in accordance with the recently revised directive from Secretary of Defense Louis Johnson to the Board, which provides that one member from each of the three military Departments shall be either an Under or Assistant Secretary of the department.

Army representatives are Archibald S. Alexander, the Assistant Secretary of the Army, and General Mark W. Clark, Chief, Army Field Forces. Navy members are Dan A. Kimball, Under Secretary, and Rear Admiral R. P. Briscoe, Director, Fleet Operational Readiness Division, Office of the Chief of Naval Operations. Representing the Air Force are Arthur S. Barrows, Under Secretary, and Lieutenant General Benjamin W. Chidlaw, Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio.

Dr. Karl T. Compton, chairman of the corporation of the Massachusetts Institute of Technology, who has been Chairman of the Research and Development Board since October 15, 1948, will continue to direct the activities of the seven-man board.

The Board, since its formation under the National Security Act of 1947, has been charged with preparing an integrated program of research and development for military purposes. It has been given the added responsibility of determining that such programs are carried out by military departments, and of directing changes in emphasis upon existing programs and projects, including the curtailment of programs or projects deemed to be unwarranted.

## Haverford College Establishes S.S.R.S., New Science Society

The formation of the Society for Social Responsibility in Science has been established at Haverford College, Haverford, Pa., by a group of scientists and engineers from several states who convened at a week-end session. In part the aims of the group are stated as a wish "to foster throughout the world a tradition of personal moral responsibility for the consequences for humanity of professional activity, with emphasis on constructive alternatives to militarism; to embody in this tradition the principle that the individual must abstain from destructive work and devote himself to constructive work, according to his own moral judgment."

## Buenos Aires Section Meeting

The celebration of the tenth anniversary of the inception of the Buenos Aires Section of the IRE was observed at its annual Engineering Week, held from October 31 to November 6.

## Radio Station WWV's Signal Improves Propagation Services

Improvement of one of the technical radio broadcast services of the National Bureau of Standards' Central Radio Propagation Laboratory will result from the new broadcast signal of the Bureau's radio station WWV. This signal, a warning of unstable conditions in the ionosphere, provides additional data on ionospheric disturbances, information of vital significance to the Armed Services and the communications industry in maintaining uninterrupted long-distance radio communications. It became effective on November 1.

Heretofore two grades of propagation conditions have been recognized in the notices given at nineteen and forty-nine minutes past each hour by station WWV, which continuously broadcasts standard radio frequencies, time announcements, and the standard musical pitch in addition to the radio propagation disturbance notices.

The Letter "N" (in International Morse Code) repeated several times has signified normal conditions, while the letter "W" has constituted a warning that disturbed conditions were present or expected within 12 hours. A third category, indicating unstable conditions, and denoted by the letter "U," is now being used when the forecasters at the CRPL's warning center expect satisfactory reception of short-wave communication or broadcast services employing high-power transmitting equipment operating on the recommended frequency, but poor results on less well equipped services.

Such conditions often occur as major disturbances subside. Although point-to-point communication links are able to resume reliable operation, mobile services, and short-wave broadcasts continue to experience difficulty. The propagation disturbance notices, broadcast in International Morse Code, primarily refer to the North Atlantic Radio circuits.

## Coast and Geodetic Survey Publishes New World Chart

Publication of a new world chart centered on the control tower at La Guardia airport has been announced by the United States Coast and Geodetic Survey.

The new chart, suggested by E. O. Cutler, consulting engineer, is produced on the azimuthal equidistant projection, valuable for radio and aeronautical operations. This projection has found wide applications in recent years for determining true distances and azimuths from a given point to any other point on the globe.

Distances and directions can be determined with a high degree of accuracy from the point of tangency which is the center point located at LaGuardia Airport control tower. A straight line drawn on the chart from New York City to any other point on the earth's surface shows the shortest route to that point and places traversed by such a route can be seen at a glance.

The chart, number 3042, is available at $0.40 a copy at any U. S. Coast and Geodetic Survey Office and at many booksellers.

## Research Board Responsibility Extended by Defense Secretary

Extension of the authority and responsibility of the Research and Development Board in compliance with the terms of the recent amendments to the National Security Act will result from a directive issued by Secretary of Defense Louis Johnson.

According to Dr. Karl T. Compton, Chairman of the Research and Development Board, "Another significant step has just been taken toward the achievement of a truly effective program of military research in the United States. The Research and Development Board now has, in addition to the responsibility for formulating a complete integrated program of research and development for military purposes, the authority to determine whether its program is being carried out by the three military departments.

"In specific terms, this means that the board may, as it deems necessary, direct changes in the programs of the services, including the initiation of new projects, the increase of effort in certain areas, and the decrease or curtailment of effort in other areas."

### Calendar of COMING EVENTS

1949 Annual Meeting, National Society of Professional Engineers, Houston, Texas, December 8–10

**Southwestern IRE Conference, Baker Hotel, Dallas, Texas, December 9–10**

AAAS 116th Annual Meeting, New York City, December 26–31

**1950 IRE National Convention, New York, N. Y., March 6–9**

**1950 IRE Technical Conference, Dayton, Ohio, May 3–5**

Armed Forces Communications Association 1950 Annual Meeting, April 26, Photographic Center, Astoria, L. I., N. Y.; May 12, New York City: May 13, Signal Corps Center, Fort Monmouth, N. J.

## General Electric Television Equipment Installed in Italy

Installation of the first American television transmitter in Europe at Turin, Italy, has been announced by the General Electric Company. Telecasting began from Turin on September 11, and covers approximately 50 miles in Northwest Italy.

The main features of the installation are a studio equipped with three cameras and programming facilities, a microwave link to relay the programs to the transmitter site, and a 5-kw transmitter of the latest design.

## SMPE Recommends Allocations For Television in Theaters

Frequency allocations for theater television have been requested from the FCC by the Society of Motion Picture Engineers under the chairmanship of D. E. Hyndman. According to the proposal, programs for theter television would be picked up from remote field locations, television studios or theaters, then would be sent to a central studio or transmitter, and then distributed to theaters that wish to present the program on their screens. Channels of radio frequencies would be required to carry the picture and sound from point of origin to theaters either on a local basis, between nearby cities, or on a nation-wide basis, depending on its commercial success.

Society engineers are of the opinion that picture quality would have to be as good as motion pictures are today. They recommended that the Commission provide wide enough channels to allow development in that direction.

Improved quality would have to begin from the present broadcast standards of 525-line black and white television. Channels 50 Mc wide, it was estimated, would be needed to give high-quality pictures in black and white, and subsequently in full color also.

According to the SMPE, as many as 60 different channels might be needed for a complete and thoroughly competitive nation-wide television system. In any given locality, fewer channels might provide adequate service.

Conferences have been held by SMPE recently with Theater Owners of America, the Motion Picture Association, and several other industrial groups in an attempt to provide the industry with a well-rounded picture of what theater television means technically.

## New Coaxial Cable Now Serves Philadelphia-New York Area

Hundreds of additional telephone conversations and three more television channels between New York and Philadelphia have been placed in service by the introduction of a new Bell System coaxial cable, according to the Long Lines Department of the American Telephone and Telegraph Company. It will connect at Philadelphia with an already existing cable to form part of another communication link supplying more long-distance telephone and video program facilities both south and west of the city.

For television purposes it will be equipped to provide two more channels from New York to Philadelphia and one more in the reverse direction. A total of five channels will be available to carry programs in the southbound direction and two for northbound transmission.

At Philadelphia, the new cable joins another coaxial link leading to Baltimore and Washington. It is a joint project of the New York Telephone Company, the New Jersey Bell Telephone Company, the Bell Telephone Company of Pennsylvania, and the Long Lines Department of the AT& T.

## IRE Executive Committee Approves New Groups

Approval of the Professional Group on Vehicular and Railroad Radio Communications and establishment of the Professional Group on Broadcast and Television Receivers has been granted by the Executive Committee of the IRE.

Officers of the Professional Group on Vehicular and Railroad Radio Communications are as follows: A. B. Buchanan, chairman, F. T. Budelman, vice-chairman, P. A. Penhollow, secretary; and administrative committee members: E. C. Denstaedt, C. N. Kimball, R. H. I. Lee, D. E. Noble, Waldo Shipman, R. C. Stinson, and H. E. Weppler.

Following a recommendation for the formation of a Professional Group on Broadcast and Television Receivers, an administrative committee was named as follows: J. E. Brown, Virgil M. Graham, R. A. Hackbusch, D. D. Israel, I. J. Kaar, and Henry C. Sheve.

## Annual Spring Exhibition Of British Radio Industry

Announcement has been made of the seventh annual exhibition of British Components, Valves and Test Gear for the radio, television, electronic and telecommunication industries. It will be held Monday, April 17, to Wednesday, April 19, 1950, in the Great Hall, Grosvenor House, Park Lane, London, W.1.

Admission is by invitation of the organizers, the Radio and Electronic Component Manufacturers' Federation, 22 Surrey Street, Strand, London, WC2.

## Radio Inventions, Inc. Now Is Named Hogan Laboratories, Inc.

The corporate name of Radio Inventions, Inc., John V. L. Hogan's research and development laboratory which specializes in facsimile, has been changed to Hogan Laboratories, Inc.

It is felt that the change in name is appropriate at this time, because Mr. Hogan is now devoting full time to the supervision of the engineering and development work of the laboratory, and because the organization has been called upon by the government and private industry to undertake projects far afield from that implied by the former corporate name. The company was founded in 1929, and will remain unchanged in personnel and location.

## Structural Products Produce All-Glass Television Bulbs

All-glass rectangular television bulbs are being produced successfully by the American Structural Products Company, subsidiary of Owens-Illinois Glass Company, according to Stanley J. McGiveran, President of the Company, which is a subsidiary of Owens-Illinois Glass Company.

The new rectangular bulb is the result of extensive research, and will give television tube manufacturers an ideal all-glass bulb designed to receive 100 per cent of the transmitted television picture.

# Industrial Engineering Notes[1]

### Television News

**The FCC has announced extension of the color phase of its television hearing** into December with the **report** that **no important decisions** on color television, the lifting of the TV "freeze," or expansion of television broadcasting into the UHF **will be made before 1950.** Outlining a schedule for completing the color phase of the television hearing, the FCC said cross-examination of the witness will not begin until December 5. . . . Five members of the FCC, members of the RMA Television Committee, leading industry engineers, and others, viewed prolonged demonstration of the proposed CBS color television system at the FCC television hearing in Washington. RCA gave a similar demonstration of its proposed electronic color television system before a similar audience. . . . It also viewed a demonstration by Color Television, Inc., at San Francisco . . . . **The Radio Technical Commission of the Ministry of Communications and Public Works** recently adopted regulations and standards for a Brazilian television service, according to information received by the U. S. Department of Commerce. The regulations provide for 12 channels and two different standards because the areas to be served have different power supplies. The government adopted a 525 line system with 60 cycles for the Sao Paulo area, and 625 lines with 50 cycles for the Rio de Janeiro area. Concessions already have been granted for two stations at Rio de Janeiro and one at Sao Paulo. . . . **United States** preparatory **work for** the sixth meeting of the **International Radio Consultative Committee** (CCIR) of the International Telecommunications Union has been started by the Study Group to further plan for the meeting at Praha, Czechoslovakia, in 1951. Curtis B. Plummer, of the FCC, is Chairman of the U. S. Preparatory Committee for Study Group No. 11, which will consider television problems, including questions relating to single sideband. The group is working on recommendations and questions to be considered in drafting the U.S. position.

### FCC Actions

**Appearing as Chairman of the RMA-IRE Joint Technical Advisory Committee, Donald G. Fink was** the **first witness when** the **FCC** television **hearing opened** Monday morning, September 26. His direct testimony consumed only an hour, but his direct examination by several Commissioners and FCC legal and technical aides occupied the remainder of the day. After describing the methods utilized in evaluating some nine possible color television systems, Chairman Fink said, "JTAC is of the opinion that sufficient information is not available on these systems, and on their operation in the field, to permit a definite comparison of their suitability for public service." Mr. Fink cited numerous technical differences between the nine systems and emphasized that JTAC has not taken sides on the claims of the various proponents of color TV systems. He explained that JTAC does not oppose color television, but believes that further demonstrations and tests are needed before a final decision is made by the FCC. "Following the determination to standardize on a particular color system, and prior to the final adoption of standards for commercial use," he said "a public field test of at least six months duration should be undertaken to assure that the proposed service can, in fact, be rendered." . . . **The FCC has granted a petition of the Allen B. DuMont Laboratories, Inc. for comparative demonstrations** early in November of black-and-white versus color receivers. The petition asked that proponents of color systems be required to include comparable demonstrations of black-and-white commercial systems under "conditions controlled by the Commission and that this topic be the subject of public presentation before the Commission in advance of any such demonstrations." The FCC was also asked to consider the "availability of the equipment employed by the sponsored systems for utilization under commercial conditions." . . . **Total investment in taxi radio equipment is "nearing $30 million,"** FCC Commissioner George E. Sterling said in an address at the annual convention of the National Association of Taxicab Owners at Buffalo, N. Y. Two-way radio for cabs has been authorized by the FCC for "two-thirds of all the taxicabs in the United States." There are approximately 2,700 authorized radio taxicab stations serving a total of 55,000 cabs. Many installations are completed and in use, others are underway, Commissioner Sterling added.

### New Heater Compensation Method

Scientists at the National Bureau of Standards have developed a new method of compensating for line-voltage changes in stabilized current power supplies. The Bureau reports that in the new circuit arrangement, heater-voltage fluctuations are used to compensate for the line-voltage fluctuations, thus increasing the stability of the output voltage. It reports that the new method can be used to good advantage in power supplies for such constant-current devices as direct-current amplifiers and microwave oscillators.

### Cathode-Ray Tube Sales Rising

Sales of television-receiver type cathode-ray tubes increased during the second quarter of the year, according to the RMA. Second quarter sales of 77,054 TV picture tubes values at $23,123,698 were reported by tube manufacturers, as compared with 686,620 units valued at $21,971,869 in the first quarter of 1949.

### Radio Sales Decreased In July

July sales of appliance and specialty wholesalers, including radios, dropped 10 per cent under sales in June and 8 per cent below those of July, 1948, according to the Department of Commerce. Sales during the first seven months of 1949 were 6 per cent below the corresponding 1948 period.

[1] The data on which these Notes are based were selected, by permission, from "*Industry Reports*," issues of Sept. 19, Sept. 23, Sept. 30, Oct. 7, Oct. 14, published by the Radio Manufacturers' Association, whose helpful attitude is gladly acknowledged.

# IRE People

**Frank B. Jewett** (F'20), for many years vice-president of the American Telephone and Telegraph Company, and former president of the National Academy of Sciences, has been awarded the 1950 medal of the Industrial Research Institute, Inc.

The medal is awarded annually for "outstanding accomplishment in leadership or management of industrial research which contributes broadly to the development of industry or the public welfare."

Dr. Jewett served as president of Bell Telephone Laboratories from its incorporation from 1925 until 1940. Previously he had served as assistant chief engineer, chief engineer, and vice-president of the Western Electric Company, manufacturing, and supply unit of the Bell System.

During World War II, Dr. Jewett was a major contributor to the activities of the National Research Council and the National Defense Research Committee of the Office of Scientific Research and Development, the top civilian agency which co-ordinated the efforts of thousands of civilian scientists. He has been honored by many universities, colleges, and professional societies, and was president of the National Academy of Sciences from 1939 to 1947.

❖

**Clinton Richards Hanna** (M'28–SM'43), associate director of the research laboratories, Westinghouse Electric Corporation, Pittsburgh, Pa., has been awarded the Howard N. Potts Medal in recognition of his initiative in the conception and development of the Tank Gun Stabilizer. The invention won for Dr. Hanna a Presidential Citation in 1942. This device helps to attain accuracy of fire while a tank is in motion on rough terrain, and secures a greater number of aimed hits than were formerly possible.

Dr. Hanna's achievements include the design of the Silverstat, an automatic voltage regulator first used for control of generators and used since 1938 on motors, turbines, or wherever automatic-voltage control is required. He directed development of the Westinghouse Photophone, one of the first successful methods of producing sound motion pictures.

More than ninety patients here and abroad are held by Dr. Hanna and he is the author of many technical works, included among which are "The Function and Design or Horns for Loud Speakers," "Design of Telephone Receivers for Loud Speaking Purposes," and "Loud Speakers of High Efficiency and Load Capacity."

Dr. Hanna, who is a native of Indianapolis, received the bachelor's degree from Purdue University in 1922. In 1926 Purdue awarded him the professional E.E. degree, and in 1945 an honorary doctor of engineering degree.

He joined the Westinghouse Corporation in 1922 and was active in the development of loud speakers and sound motion picture apparatus until 1930. He was then made manager of the development division of the research department, becoming manager of the electromechanical division in the same department in 1936. He has held his present post since 1944.

❖

**Charles J. Breitwieser** (A'37), chief of electronics and engineering laboratories for the San Diego, Calif., Division of Consolidated Vultee Aircraft Corp., has been awarded an honorary degree of Doctor of Science from the University of North Dakota, his alma mater.

He was cited for his contributions in the field of guidance and control of guided missiles; his efforts in the development of a high-voltage, alternating current, electrical system for large aircraft; his pioneering in radiotherapy and electrosurgery and in the general field of hyperpyrexia, or artificial fever; and his achievements in the fields of radio and television. The degree was conferred by his father, Dr. J. V. Breitwieser, Dean of the University's School of Education and summer school director.

A native of Colorado Springs, Dr. Breitwieser was graduated from the University of North Dakota in 1930 with a degree of bachelor of science in electrical engineering. He earned the M.S. degree from California Institute of Technology in 1933.

He became associated with Consolidated Vultee in 1942 as a staff engineer in charge of radio and electrical engineering. He holds patents for an aircraft wing flap synchronizer, a new system of radio communication, and also for electromedical equipment. He is a member of the Research and Development Board for the National Military Establishment.

Dr. Breitwieser's articles have been published in the *Archives of Physical Medicine*, the *Pacific Journal of Homopathy* the *Journal of the Osteopathic Association of America*, and other journals in this country and abroad.

❖

**Everhard H. B. Bartelink** (A'29–M'37–SM'43), has been named assistant to the director of research at General Precision Laboratory, Pleasantville, N. Y. Formerly he was head of the radio department of the General Telephone Corp.

Dr. Bartelink, who was born in Zutphen, Holland, received the degree in electrical engineering from Delft University, and the Ph.D. in physics from Munich University. In addition to the General Telephone Corp., he has served on the technical staffs of the Netherlands Telephone Company, General Electric, and Radiation Laboratory at MIT.

**August J. Mundt** (M'45), formerly general superintendent of training and personnel of the Western Union Telegraph Company, has been appointed Dean of Coordination at Walter Hervey Junior College. He retired in September from Western Union after twenty-seven years of service, both as an engineer and in personnel work.

Dean Mundt was graduated from Princeton University in 1915, and completed studies at Princeton University Graduate School of Engineering in 1917. He was an instructor in physics and electrical engineering at Princeton.

In his new association he will supervise the co-operative education program at Hervey and co-ordinate activities of the students in the work-study plan. He will be in charge of all student on-the-job employment in the engineering, business, and liberal arts curricula.

Dean Mundt is a member of the American Society for Engineering Education, and the American Institute of Electrical Engineering. For the past five years, he has been a member of the N. Y. Engineers Committee on Student Guidance; he was formerly a member of the Electrical Technology Advisory Commission for the New York State Institute of Applied Arts and Sciences.

❖

**Ross H. Reynolds, Jr.** (A'46) has been appointed a district representative for the General Electric Company's electronics department. He will be responsible for sales of marine electronic equipment in the New England, New York, and Atlantic districts of the department.

Mr. Reynolds, who has been with General Electric since 1940, is a native of Raleigh, N. C. He received the electrical engineering degree from North Carolina State College. When he joined General Electric, he was assigned to the instrument engineering section at the West Lynn, Mass., Works. From 1941 until 1946 he served in the U. S. Army as a member of the Signal Corps. He served overseas for two and one-half years, holding the rank of major.

Rejoining the electronics department of GE in April, 1946, he was assigned to radar engineering at Syracuse. In July, 1948, he was transferred to broadcast sales.

Mr. Reynolds is a member of the American Institute of Electrical Engineers.

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**W. M. Gottschalk** (S'41–A'45) has been appointed to the microwave and tube section of the newly created Research Division of the Raytheon Manufacturing Company, Waltham, Mass.

**Joseph F. Bozelli** (A'46) has been appointed assistant sales manager of the L. S. Brach Manufacturing Corp. of Newark, N. J. He will supervise and direct a new television antenna promotion for the Brach Corp., active in the electronic and electrical fields for over forty-two years.

Formerly, he was sales engineer with the JFD Mfg. Co. of Brooklyn, N. Y., in charge of manufacturing accounts, and earlier he had been sales production manager with the Fred Goat Co., also in Brooklyn. He has been associated with electronics for the last 10 years.

Mr. Bozelli holds a pilot's license and was a member of the Civil Air Patrol for three years. With 100,000 miles logged on Passenger Air Lines, he was recently admitted to United Air Lines' exclusive 100,000 Mile Club.

Mr. Bozelli's appointment coincides with a new television antenna and television accessory program soon to be announced.

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**William C. Hahn** (A'36–SM'45), research associate in electronics at The Knolls research laboratory of the General Electric Company, died recently en route to the hospital. Mr. Hahn had been associated with General Electric since his graduation from Massachusetts Institute of Technology, where he earned the B.S. degree in 1923. Upon his completion of a student engineering course, GE sent him to its Chicago office. From 1933 he worked in the engineering general department at Schenectady.

A native of Illinois, Mr. Hahn was 48 years old at the time of his death. He attended high school in Kenosha, Wis., and for three years was a midshipman at the U. S. Naval Academy, Annapolis, Md.

Mr. Hahn was a member of the American Institute of Physics, the New York State Society of Professional Engineers, the Schenectady GE Engineers Association, the Whitney Club, and the GE Quarter-Century Club.

**Martin M. Freundlich** (A'38–SM'45) has been placed in charge of the newly established tube laboratory in the Applied Physics Section of Airborne Instruments Laboratory, Mineola, L. I., N. Y. Dr. Freundlich, who has been prominent for many years in vacuum-tube research and development, will conduct research on storage tubes and other vacuum devices which will help facilitate the laboratory's expanding program of electronic research and development.

He has been engaged in television research at Columbia Broadcasting System for more than ten years. There, in his tube laboratory, he did pioneer research on tubes for color television and also on early projection television tubes.

During the war Dr. Freundlich was occupied at North American Phillips for a period of one and one-half years with the development of radar and television cathode-ray tubes.

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# Books

### Atmospheric Electricity by J. Alan Chalmers

Published (1949) by Oxford University Press, 114 Fifth Ave. New York 11, N. Y. 163 pages+6-page index+6 page references. 36 figures. 5½×9. $3.75.

In preparing this book the author sets for himself a twofold purpose: first, of providing the reader with an introduction to the subject of atmospheric electricity; and second, to give the research worker a comprehensive literature survey of previous work in the field through citing and briefly discussing 248 references.

"Atmospheric Electricity" is divided into twelve chapters under titles: Historical Introduction; Fundamental Principles and General Summary; The Ions in the Atmosphere; The Earth's Vertical Field; The Conductivity of the Air; The Air-Earth Current; Point Discharge Currents; Precipitation Currents; The Transfer of Charge; The Thunder-Cloud; The Lightning-Flash; and the Separation of Charge.

Presentation of the subjects listed is largely through a chronological discussion of the references cited without seriously attempting to integrate all the various contributions into coherent reading. The omission of very important work recently done in the United States is indeed unfortunate. For example, the excellent contributions of Workman and Holzer have been neglected; the work of Byers and his group of thunderstorms has been omitted; no adequate discussion has been made of the detection and significance of radiation (sferics) originating in electrical storms or of the relationship of precipitation static to atmospheric electricity. In the same vein of criticism, there appears a lack of recognition of important research reported by German workers in the field. The deliberate omission of ionospheric exploration by radio methods and cosmic rays is understood and appreciated, for a lack of connection exists between such investigations and the area of activity which the book emphasizes.

It is not a lengthy treatise, and in the pages allowed it is perhaps unfair to expect a fully comprehensive treatment. The material presented is interesting, easily readable, and almost nonmathematical. Its reading public should be largely physicists interested in atmospheric phenomena, meteorologists, and, to a limited extent, radio engineers concerned with such activities as radio-sonde techniques, sferics, etc. However, almost any technically minded person would enjoy an evening browsing through the contents and acquiring more conversance with the tantalizing subject of atmospheric electricity.

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### Pulses and Transients in Communication Circuits by Colin Cherry

Published (1949) by Chapman and Hall Ltd., London. 310 pages+5-page index+xvi pages. 129 figures. 5½×8½.

The most important function of this new volume will be to help engineers to put transient analysis in its proper perspective in the subject of communications theory. It is intended "as an introduction to circuit transient analysis for communications engineers . . . using, whenever, possible, rigorous physical arguments and only elementary mathematics . . . . Electric waveforms are dealt with, rather than analytical functions, thus giving the book a geometrical or 'oscillographic' flavour."

The first three chapters of the book dealing with the basis of network analysis, the frequency spectra of modulated wave pulses and transients, and the steady-state, put the reader's knowledge of transients and networks on a sound footing. Chapter 4, which treats the transient response of networks, is followed by an excellent chapter which discusses the "use and abuse" of idealized response characteristics in transient analysis. A chapter on multistage amplifiers includes useful sections on the constancy of the bandwidth-gain product and on the relation between signal-to-noise ratio and frequency response. Chapter 7 deals with assymetric sideband channels, including suppressed sideband radio and television working. The final chapter on reflection and echo effects is largely relevant to the pulse-testing of networks, on which the author is an expert.

The book covers the subject quite comprehensively and with a practical emphasis that lends conviction. Although the theoretical treatment of Fourier-analysis in Chapter 2 may be bettered elsewhere, the clear exposition of its application to wave forms and their spectra is excellent. The statements of fundamental theorems of network analysis are also made very clearly in the early chapters.

A comprehensive list of references is provided at the end of each chapter and a list of symbols is also given. The book is well illustrated and is free from obvious errors. It is recommended as an up-to-date contribution to literature for the graduate engineer in radio, radar, television, and teaching.

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# Books (continued)

### Photoelectricity and Its Application by Vladimir K. Zworykin and E. G. Ramberg

Published (1949) by John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 478 pages+10-page subject index+6-page author index+xii pages. 6×9¼.

In the early 1930's there were a number of books on photoelectricity which rather thoroughly covered the subject up to that time. Since then particular aspects have been covered, but there has been an increasing need for a more inclusive up-to-date summary.

"Photoelectricity and Its Application" emphasizes the great progress in recent years. For this reason the treatment is entirely new and not a revision of the former book on "Photocells and Their Applications" by Zworykin and Wilson.

The authors discuss radiant energy, thermal and gaseous sources, and photometric measurements. The general theory of the emissive effect is reviewed, and photocathode surfaces discussed in some detail. Two chapters are devoted to the materials and methods of preparing such tubes. The vacuum, the gas-filled, the multiplier, and the image tubes each have a chapter, as do the photoconducive, and the photovoltaic effects. More than half the book is devoted to numerous circuits and applications. Some of the newest applications are clearly described as the television camera tubes, light beam signalling, infrared detection, and the use of multipliers at very low light levels. There is a short chapter on photo cells in the future, followed by an appendix of five tables covering the atomic elements, units and conversion factors, physical constants, and relative luminosity factors. MKS units are used throughout.

While the treatment is in general up-to-date, a couple of comments may be made in this respect. On page 24 the new candle based on 60 candles per square centimeter for the brightness of a black body at the freezing temperature of platinum is referred to as an expected future use. Actually it has been an accepted standard since January 1, 1948, and corresponding to it, on page 477, 1 watt=660 lumens of radiation at 5,550 A.U.

In the discussion of electrometer tubes and circuits on page 255 and following, one does not find a reference to an important bridge circuit of improved stability which utilizes a single electrometer tube containing two anode and grid structures with a common filament (G.E. Co. tube No. 5674). In this manner, fluctuations in the emission are balanced out, which is not possible with separate tubes.

The book covers so much ground that the treatment necessarily is condensed. Mathematical discussions are confined to footnotes, and the subject is clearly presented with excellent figures. It is well recommended for anyone interested in photoelectricity, and especially so for those concerned with the more practical aspects.

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### Patent Law by Chester H. Biesterfeld

Published (1949) by John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 236 pages+5-page index+3-page appendix+18-page table of cases+2-page bibliography+viii pages. 6×9. $4.00.

Mr. Biesterfeld's book on patents, which is a second edition to the previous volume, covers the subject with a reasonable comprehension and explanation. It reviews the origin of the creation of the Patent Law of the United States under the Constitution and of the prior authorization in England, and gives the broad general background required to understand the theory and purpose of such legislation by Congress. It also covers, generally, each individual form of patent, although it stresses least those in the electronic field. The present trend toward electrical patents being applied in so many fields is not so thoroughly covered in the book as patents on other subjects.

The information given in the book under the topic heading is reasonably complete, and the author's explanation of varying decisions and of the trend of judicial determination of these conflicting considerations is most interesting, informative, and gives a very good view of how in many instances legislation and judicial construction is changing in the field, and how we might consider under each topic the present established rule and trend.

It is impossible, of course, in one volume to do any more than highlight the decisions indicating the judicial construction of the various questioned points involving patents and their adjucation and construction, but it would seem that within the confines of one small volume the author has done a very competent job, and the book does give anyone interested in each of these disputed questions the general controlling decisions, and the author's conclusion as to their meaning.

The book would appeal to engineers, lawyers who practice not exclusively in patents, and inventors who need to know the general rules to aid them in their activities.

The book presents the facts clearly on each subject, to some extent following the general presentation of a college lecture course, and is easily readable and can be understood by anyone having the slightest background or education in the subject. It is carefully laid out on the various subjects and is in no way repetitious. The book, being a re-issue and a second edition of an existing one, has had all possible inconsistencies ironed out, and follows through on the various details of patent construction and decisions in a very smooth and uniform development.

This reviewer's conclusion of the book is that it is a worthwhile edition, bringing the first book up-to-date, and that the author's conclusions as to the varying decisions and trends of the courts construing patent law are worthwhile, and will reward any reader who examines the book thoroughly.

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### Electrical Transmission of Power and Signals by Edward W. Kimbark

Published (1949) by John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 439 pages+21-page index+xi pages. 215 figures. 6×9. $6.00.

Written for undergraduate students in electrical engineering, the text assumes knowledge of the usual courses on dc and ac circuits with lumped parameters. The purpose of the text is to give the students their first detailed treatment of circuits with distributed parameters.

The book deals with basic transmission theory and its applications to three particular fields: power, telephony, and ultra-high frequencies. To avoid unnecessary duplication and save the student time, a feature of the book is the idea that these three topics may be advantageously developed from a single theoretical treatment, and the book has been written with this underlying objective.

The theoretical treatment has three main divisions: transmission-line parameters, steady-state phenomena, and transient phenomena. The chapters which deal with transmission-line parameters occupy 86 pages, and deal with various types of lines ranging from simple two-conductor lines to more complicated arrangements using stranded and ground-return conductors. The chapters which logically fall under steady-state phenomena occupy 143 pages. The topics covered are: smooth transmission lines, lumpy lines, transmission line charts, impedance matching filters, and skin effect. The theory of smooth transmission lines is approached through setting up and solving the differential equations instead of the treatment wherein a smooth line is regarded as the limiting case of a recurrent ladder network. The treatment of the other topics is conventional. Transient phenomena are covered in a single chapter of 34 pages. Some of the more important transient phenomena are described and formulas are developed for the transients in loss-free lines.

The application of the theoretical treatment to particular types of transmission systems is dealt with in four chapters which occupy a total of 119 pages. These chapters are entitled, "Electric Power Transmission," "Telephone and Telegraph Transmission," "Radio Frequency Transmission Lines," and "Waveguides." The material presented in these chapters is largely of an introductory nature.

Another noteworthy feature of this book is the 51-page appendix which lists the significant characteristics of a wide variety of transmission lines. This should prove valuable not only to students, but also to those working in the fields of communication and power transmission.

In general, this new volume fulfills the objective of rigorously setting forth fundamental transmission theory in a straightforward manner, and shows how this theory may be applied to widely different types of transmission systems.

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# Books (continued)

### Electronic Time Measurements, Edited by Britton Chance, Robert I. Hulsizer, Edward F. MacNichol, and Frederick C. Williams

Published (1949) by McGraw-Hill Book Co., Inc., 330 W. 42 Street, New York, N. Y. 525 pages+10-page index+xviii pages. 356 figures. 6×9¼. $7.00.

One of the most important functions of a radar system is the accurate location of the objects from which reflections take place. In order to do this, an accurate measure of the time interval between emission of the pulse from the transmitting antenna and reception at the receiving antenna is required. In the so-called hyperbolic navigation system an accurate measure of the time interval between the arrival of two or more pulses is necessary. This book covers the fundamental factors involved in making both such measurements and describes the status of practical apparatus for making them during and up to the end of World War II. Although most of the material is based on the author's personal experience at the MIT Radiation Laboratory, a certain amount treated more sketchily is based on the developments in other laboratories.

The arrangement of material is logical and is exceptionally well co-ordinated for a book written by so many individuals. Although the book should be easy reading for technical graduates with a good understanding of nonlinear circuits, the less initiated will find a prior reading or at least reference to Vol. 19 of The Radiation Laboratory Series useful, if he is interested in an understanding of circuit details in addition to the broad aspects of the material that is covered. The treatment is descriptive rather than mathematical, and is replete with detailed circuit diagrams showing the application to numerous equipments.

In the early part of the book a general review is given of various systems for measuring distance and speed by the timed transmission of radio waves, including phase- and frequency-modulation systems, but the remainder of the volume is devoted almost entirely to the techniques used in pulse apparatus. The general techniques used for the timing of pulses is covered in one chapter. Following this are three chapters concerned with the generation of fixed and movable indices, i.e., covering essentially the generation of a series of accurately determined scale markers. Following this the methods are described which are used in systems where the determination of the timing of the received signal depends largely on operator manipulation or observation. The various types of cathode-ray tube displays are included in this section. The next two chapters deal with methods for determining the time of arrival of the received pulse by means of equipment whose accuracy depends in the main on an automatic positioning of the reading or operating index by means of the received pulse. In this section angular position measurement is also treated briefly. The last three chapters do not follow the logical sequence of the book too well, and could, with equal or perhaps better logic, have been placed in one of the other volumes of the Radiation Laboratory series. Chapters 10 and 11 cover Special Data Transmission Systems and Relay Radar Systems, and Chapter 12 deals with Delay and Cancellation of Recurrent Wave Trains. Although the use of storage tubes for this purpose is briefly referred to, it is not treated in detail and the chapter is mainly devoted to the mercury delay line system. Readers interested in storage tube or electrical circuit methods would do better to read chapters in Vol. 19 of the Radiation Laboratory Series.

"Electronic Time Measurements" will for many years be the outstanding reference work on the subject, and should have a place in any library where there is an interest in the development of circuits for this purpose.

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### Invention and Innovation in the Radio Industry by W. Rupert MacLaurin

Published (1949) by the Macmillan Company, New York, N. Y. 265 pages+6-page index+7-page bibliography+xvi pages. 5¾×8¼. $6.00.

Based upon a series of studies of invention and innovation, financed through a Rockefeller Foundation grant, the volume is an excellent exposition of the impact of invention upon the structure of the radio industry. It is not a history of radio, but deals in part with the inventions of some of the pioneer scientists and engineers.

Distinctions are made between the research scientist, the inventor, and the business innovator in their respective relations to technological changes, and stress is placed on the author's opinion of the value of scientific research in industrial organizations. The author states: "In the United States it was not until the large and well-established electrical companies turned their attention to radio that research became more business-like and more co-ordinated. At the same time, it lost some of its spark and originality."

Mr. MacLaurin includes considerable authentic material dealing with the statistical history of radio manufcturing companies, and the economic, industrial, and patent circumstances which affected their growths, or which accelerated their liquidation. He presents useful information about the functioning of industrial laboratories, manufacturing processes, and merchandising and sales. The book includes a considerable amount of well-organized data on the general subject of radio patents. There is statistical material dealing with various of the early struggles in the courts in the connection with the legal establishment of priority of discovery.

The author certainly was not at pains to minimize Marconi's technological contributions to radio, even though in particular paragraphs he emphasizes Marconi's use of researches and inventions of others. The record presented of de Forest's radio achievements is excellent, but is not enhanced by reliance upon a discredited, scurrilous article which appeared in a popular weekly a few years ago.

There is a discrepancy in the name of the inventor of the Ultraudion circuit, but all in all the book is remarkably authentic in the coverage of invention and discovery. It should find wide acceptance among radio executives, research scientists, engineers, and students. In the text there is high inspiration, for in the accounting of what has thus been accomplished in radio, television, and related arts, a vision takes shape of what lies ahead in the way of opportunity.

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### FM Transmission and Reception by John F. Rider and Seymour D. Uslan

Published (1949) by John F. Rider, Publishers, Inc., 404 Fourth Ave., New York 16, N. Y. 30 pages+10-page appendix+4-page bibliography+5-page index+vi pages. 201 figures. 5½×8½.

This is the ninth printing of a book which was first printed in 1948. It differs from previous printings chiefly in the inclusion of a set of questions at the end of each chapter, to make the text more useful to technical schools, as well as to the reader who uses the text for self-study.

The book is divided into two parts. In the first, the underlying theory of frequency and phase modulation is discussed as well as the propagation of FM signals, the basic characteristics of FM transmitters, and an analysis of those in use today. The coverage of FM transmitters is especially complete.

The second part of the book discusses the latest types of transmitting and receiving antennas. Every stage in an FM receiver is explained carefully, with special attention to the four different types of FM detectors. The last two chapters take up the alignment and servicing of FM receivers.

In discussing actual hardware and circuits in transmitters and receivers, the authors do a very workmanlike job. The same cannot be said of the first two chapters, on fundamental theory. Here many pages are spent trying to explain the difference between "phase modulation" and "frequency modulation." Since neither system of modulation is often used in its pure form, it seems unfortunate that the authors felt it necesary to perpetuate the apparent differences, which usually only lead to confusion in the mind of the student. In an effort, as stated in the preface, to keep mathematics at a minimum, the instantaneous frequency is erroneously defined as the reciprocal of the period. This definition leads to a wrong result in the example given on page 15. It would seem that a student in a technical school should be mature enough to be introduced to the concept of instantaneous frequency as the time rate of change of the carrier phase angle, but nowhere in the book is this brought out explicitly.

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# Clarity in Technical Writing*

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*Summary*—Logical sequence of ideas and simplicity of literary style are the fundamental basis for clarity in technical writing. If a paper follows the general form of introduction, development, application, and conclusion, it should be readily understandable.

## I. Introduction

IN TECHNICAL PAPERS intended for publication the material must be well organized and the ideas skillfully expressed if the all-important goal of clear, effective writing is to be achieved. Numerous postwar research and development projects have stimulated widespread publication of results in every field of engineering, and, because of this mushrooming growth of technical literature, all forms of engineering writing must now meet increasingly higher standards of quality. The purpose of this paper is to discuss briefly some of the principles of organic structure and literary style which are essential to clarity in technical writing.

## II. Organization of Material

If a writer is to accept the responsibility for making his paper unquestionably clear, he must carefully arrange his written material in some orderly sequence and build it upon a logical framework. There is certainly no standard outline upon which all forms of scientific and engineering writing can be based; the broad principles discussed here, however, may serve as a general guide.

*The Summary:* The purpose of a summary or abstract is to give the reader an immediate understanding of the entire piece of writing. Since a good summary will often consist of only one or two short paragraphs, it must deal exclusively with the essential theme. There should be no attempt to provide introductory background material, to present experimental details, or to support the writer's conclusion or final results. The abstract instead should be a triple-distilled essence of all the material presented in the paper.

*The Introduction:* While the function of the summary is to condense the entire substance of the paper into a few sentences, the introduction serves a different purpose. This section should begin with a general orientation of the reader by a short historical review of related work, or by an explanation of why the project was undertaken. These introductory remarks should then lead up to a precise statement of the problem. After the reader has been oriented and the problem well defined, the introduction can be brought to a close with a brief explanation of how the problem is to be attacked.

* Decimal classification: R050. Original manuscript received by the Institute, May 26, 1949.

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*The Process of Development:* Having laid a sound foundation for the construction of the main body of the paper, the writer can next proceed to develop the fundamental idea. Whether the article is concerned with a basic research project, an engineering development, a general survey, a mathematical derivation, or any other technical treatment, the separate ideas should be presented in logical succession. The interests of clarity can best be served by arranging the subject matter so that there is an obvious relationship between cause and effect and a progressive growth of the central idea. An example of this type of development is a description of a piece of laboratory apparatus followed by a discussion of the actual experiment with the apparatus. Another example is design analysis of specified equipment, followed by a description of its construction. Still another is an evaluation of the factors comprising an engineering problem and a discussion which will lead up to recommendations for its solution. Regardless of the nature of the topic, its development will be aided by some orderly progression of ideas, such as from the known to the unknown, the simple to the complex, or the component parts to the integrated whole. In forging the chain of logic the writer must include every link.

*The Application:* After a fundamental idea or process has been introduced, explained, and logically developed, an indication may be given of how it may be applied, since the ultimate goal of all technical work is some sort of practical application. Frequently an abstract idea which is difficult to explain will be clarified when the writer shows its relationship to practical considerations that are easily understood. Moreover, a paper dealing with a tangible process, such as the development of a new measuring technique, should present a clear picture of the new method by showing how it may be applied in practice and how it is superior to previous techniques. Likewise, a report on design work should give an indication of the applications of the product or equipment. Since most technical writing is concerned with a highly specialized concept of science or engineering, the theme will often be more clearly understood if its relation to actual practice is made clear.

*The Conclusion:* While similar in scope to the abstract, the conclusion is written for a somewhat different reason. The abstract tells the reader in advance what the paper contains; the concluding section may either summarize, interpret, evaluate, or make recommendations. Usually, it will be weighted with opinion, which is seldom the case in the more factual abstract. Other functions of the conclusion are to indicate the trend of future work and to make any necessary acknowledgments. When the concluding section of a technical paper is inadequate, the writer has neglected to clarify his central theme by a recapitulation or at least a commentary on the significance of the work. No matter how well the information on the subject has been presented in the body of the article, the concluding portion will contribute added strength and meaning if properly written.

The proportions of the paper to be devoted to the introduction, development, application, and conclusion will depend entirely upon the scope of the subject and manner of treatment. In fundamental research, the process of development is generally the lengthiest portion, with little emphasis on applications. An article describing new products or machinery would, on the other hand, more likely devote most space to the section on application. Survey articles and reviews of the literature deal largely with information ordinarily found only in the introduction and conclusion. Regardless of how the various sections may be proportioned, however, the general principles of organization suggested here may be applied to any type of technical writing.

## III. Relation of Style to Meaning

When the material for the paper has been organized on a sound basis, the writer can turn to considerations of literary style. There is an important relationship between style and intelligibility, and the merit of a technical article is based upon the manner of presentation, as well as the content. When dealing with difficult or complicated concepts, the tone must be adapted to the particular class of readers for which it is intended. Where a discussion of a highly specialized or difficult topic is written for popular consumption, the author can treat the subject as if it were pleasant and comprehensible, rather than create a barrier to understanding by stressing the complexity of the problem.

In addition to tailoring the article to fit the requirements of clarity of any given group of readers, the writer should likewise emphasize some portions of the piece and subordinate others, depending on reader interest. For example, recent literature in physics journals on the transistor crystal amplifier deals mostly with physical theory, while the articles about the same crystal amplifiers in the engineering magazines emphasize practical applications. The process of subordination of ideas is vitally important not only in the over-all construction of the paper, but also in the details, down to the organization of paragraphs and even sentences. An example is the following sentence: *The gears did not mesh properly, and the machine would not operate.* The true relationship between proper meshing of the gears and the operation of the machine is not immediately clear. Subordination of the first clause to the second could be accom-

plished by a more lucid construction: *Since the gears did not mesh properly, the machine would not operate.* A little care in properly subordinating ideas throughout the paper will greatly enhance the clarity of meaning.

Another important aid to intelligibility is the use of transitional words, phrases, and sentences to serve as connecting bonds between separate ideas. Expressions such as *moreover, in addition to, however, for example, yet,* and *on the other hand* are especially helpful in the section dealing with the process of development. In technical writing, connectives should be used liberally as an aid to coherence and unity. The writer's words tend to reflect any discontinuity of thought or mental uncertainty; the deliberate use of transitional constructions will therefore serve the double purpose of clarifying the author's own thinking and of providing a smoothly flowing procession of ideas for the reader.

Finally, the keynote of all technical writing should be simplicity. If the subject is highly technical, the use of correct terminology is essential, but this is not to be confused with the use of ornate or intricate expressions. If, indeed, the chief concern of the author is to impress his readers with high-sounding wordage, he may well succeed in doing so, but the essential meaning of his paper is likely to be obscure. There is no effective substitute for a simple, direct style of writing if clarity is the ultimate aim.

## IV. Conclusion

One of the prime requisites for lucidity in a technical paper is a basic structure consisting of introduction, development, application, and conclusion. If the ideas are presented in logical sequence, and if the literary technique is simple and direct, the goal of clarity will be achieved. One criterion of the intrinsic worth of any piece of technical writing is the manner in which it is constructed, because its completeness of information and creativeness of thought will be of little value to the reader if he cannot readily understand the written word.

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# The Engineer and Industry*

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*Summary*—**This paper is directed to the engineer just beginning his career in an industrial firm. Information regarding the organization of such firms and how the engineer fits into it is covered. His typical reactions observed over the years are shown. The importance of co-operation, human relations, and trust in others is emphasized. The time required between the birth of an idea and a product is reviewed in narrative form. The importance of the engineer in society is given.**

**There have been many discussions of the technical requirements of an engineer, but not enough has been said about the other parts of an organization into which an engineer must fit. This paper is intended to explain some of the reactions of an engineer in industry, and to present the views of both the management and the engineer.**

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## School to Industry

THE ENGINEER and his mental processes are important to himself and to management. The thoughts and reasoning of an engineer from the time of his graduation from an engineering college through several years of experience in an industrial firm can be arbitrarily divided into four parts for the purpose of this discussion. The four parts in chronological order are: (1) idealism, (2) disillusionment, (3) enlightenment, and (4) realism.

The period of time required for each part varies with individuals and conditions. It is not maintained that all engineers can divide their career into these four parts, because the problem is too complex and subtle to allow such an arbitrary attack. However, it is believed that the four parts are roughly typical of a large percentage of engineers. It also appears that veterans who have had war experience before completing college will enter industry with a more mature viewpoint. This condition alters the phases of the engineer's career, so that it does not so closely follow the parts outlined in this discussion. However,

the parts listed are typical enough to warrant expansion and discussion.

### Idealism

The engineer graduates. He is full of boundless enthusiasm and ideals. He is anxious to start, obtain his just rewards of satisfaction, and receive material gain for his long years of sacrifice and study. He also wants to make his contributions to science and engineering. Upon obtaining a job as a junior engineer in a firm doing electronic development and manufacturing, he is ready to "go."

He thinks of the firm that he has selected as a great giant of efficiency and marvelous undertakings. Everything is done perfectly, everyone understands him, untold facilities, instruments, and people are at his command. In other words, he is awed and impressed. He absolutely relies on the greatness, integrity, and perfection of the company of his choice. This blissful state may last one or two years and it may only last a few months, but it is not permanent for the average man. He rapidly enters the most depressing phase of his career.

### Disillusionment

The engineer is now beginning to see the imperfections and gross inefficiencies in his firm. It is beyond his powers of comprehension how management can be so inefficient, short-sighted, heartless, "plain dumb," and still exist. He sees errors in judgment, wastefulness, unfairness, and lack of competence on the part of his associates, supervisor, and management, including all other departments. Everything is done wrong, no one will allow him to make it operate properly or listen to his ideas. If business is run this way, it is no wonder that the world is in such a sad state, he reasons. He complains about everything, but still goes along and tries. He either reaches the next stage soon, or gives up and tries another job. In one time out of 100 he was right, and has selected the wrong Company; but in most cases, if he adopts this philosophy and retains it, he will flit from one position to another and end a failure. However, most men outgrow this stage soon, and in a few years regain some of the ideals and enter the third part of their careers.

### Enlightenment

The engineer has begun to realize the value of expediency and compromise. He has learned that any organization is composed of human beings, and can be only as good as the aggregate of these individuals. The value of other types of work becomes apparent to him. He finds that each person has his own ideals, beliefs, and troubles. All people are not equally capable, honest, industrious, or conscientious, and they never will become so. There are superior, average, and poor employees. Any organization which he can find will be similarly constituted, because people are human. The management is not perfect, but they also have their problems, and are usually honestly doing their best within their own experience and ability, and with the people and facilities available to them. He now has learned that a Company is not a machine. It is people, working together cooperatively for a common purpose: the sale of a product at a profit to all concerned. His profit is in the form of salary, prestige, satisfaction, and the feeling of accomplishment. The customers' profit is in the form of a useful product at a reasonable cost. The management's profit is the same as his; money, prestige, and satisfaction. The stockholder's profit is a return on the investment, which represent savings over a long period of time.

In other words, he has learned the value of his own work and the part it plays compared to others' work; the value of tolerance and understanding; the necessity for rules, procedures and regulations; the importance of the work of all of his associates who are not engineers, such as accountants, salesmen, assemblers, buyers, and many others. He cannot create or build a product alone, but all together, the people in his firm can and do. His technical judgment and knowledge have increased to the point that his superiors learn to rely on it. In other words he "belongs," perhaps not as idealistically as when he began, but his enthusiasm is more valuable. He is a recognized part of his organization, contributes his work as a part of a team knowing that he is of no value alone; and that the others are of no value without him.

The engineer is in the rewarding part of his career. He may not be at the peak in earning capacity and his use of leisure time; but he is ready for the fourth and ultimate part of his career.

### Realism

The engineer is now a vital and smooth-working part of his organization. He may or may not be the chief engineer, but he is definitely responsible for certain products and truly has a wealth of facilities, equipment, and people at his command. Everyone is helping him and he is helping everyone else, be they engineers, salesmen, accountants, or toolmakers.

He listens to the other man's viewpoint, carefully evaluates it as related to his own, and then acts. True, he makes compromises every day. Sometimes a technical nicety is sacrificed to fit a cost estimate or a machine, or even an idiosyncrasy of a customer, salesman, or of his boss; but he knows that it is all for a purpose in the end—the sale of a satisfactory product at a profit.

He realizes that modern industry is complex and requires a well-integrated team of engineers, assemblers, toolmakers, salesmen, accountants, supervisors, buyers, and countless others; and he respects each one of them for his knowledge and experience in a particular field of modern business.

He has also learned how to make many decisions in a day without endless arguments on the pros and cons of the situation; and he is teaching less experienced people how to do the same.

He has learned the limits of his mind and body, and has reached a happy balance in work, leisure, and family relations. People like to work with him and know that if he is overruled or his idea rejected, he will not sulk and brood for days. In other words, he belongs! He is happy, respected and valuable. He is well-paid in salary, prestige, and a sense of well-being as a part of a successful organization. But above all, he is tolerant of others, because he knows that he is not perfect himself. He has reached the ultimate in his career and still has many years of successful living ahead. He has reached the fourth and last stage of his career.

The total time required to go through the three parts of the engineer's career will vary, but is usually from five to ten years. Of course, some engineers never reach the maturity and human understanding, power of expression, co-operativeness and compromise, combined with engineering proficiency, required to become happily and profitably a vital part of an industrial organization.

They either drop out, become a successful "lone worker," or are a continual source of irritation to themselves and management, and cannot understand why they are never promoted.

### Adage

This is a good point at which to stop and reiterate this age-old advice to the young engineer: "You may be the best engineer in the world, you may have more ideas than anyone else, you may be conscientious, hard-working and brilliant; but if you stay in a corner and never sell your ideas to your associates, no one, neither your firm nor civilization, will get the benefit of your genius, nor seek you and your ideas. You must learn to express yourself, both in writing and verbally. You must work with and understand people. Too much emphasis cannot be placed on the necessity of adaptation and reasonable compromise."

### From Idea to Product

A problem to the young engineer worthy of discussion because it is so often a cause for concern to him is: Why does it take so long from the proposal of an acceptable idea for a product, until it is commercially on the market; and why are so many ideas that management admits are good never used?

We must remember that there is far more to the successful sale of a product than its technical excellence. It must be available at a time when there is a demand for it. In other words, correct timing is essential. An idea or a product may be on the market either too early or too late. It does no good to offer the best product in the world if there is no demand for it. The demand can be created either by advertising and publicity, or it may naturally exist.

The product must also be competitive in price, it must be styled to be attractive to the particular customer, it must have performance and quality designed and built into it to do the job intended. It must be no better and no worse than required, or it can't be competitive.

The product must be manufacturable by the plant at your command, and it must be within the scope of capabilities and experience of your co-operating departments, such as sales and factory.

It is impossible to list all of the requirements that must be met before a particular firm can undertake to design, manufacture, and sell a new product. The inexperienced engineer cannot hope to understand and be competent in all of the necessary fields. Therefore, he must have the confidence in his management and his associates warranted by their greater experience and their successes, proven by the firm's existence.

To use a specific example which could occur, let it be assumed that the engineer works for a medium-sized firm that is engage in the design, manufacture, and sale of radio and television receivers. This firm employs several thousand people and has complete engineering, factory, and sales organizations. It also has complete manufacturing and laboratory facilities.

The engineer, during the course of his design work on a television set, has developed a new piece of test equipment for his firm's own use in the factory and laboratory. It does the job well and was developed because nothing was available on the market that would do the job satisfactorily. He has personally constructed four pieces of this equipment and made them operate properly. It appears to him that if his firm has the need for such a piece of equipment and it does the job so well, other firms and laboratories should need it and there should be a market for it. Accordingly, he proposes this to his chief, who admits it is a good idea and gives him permission to submit the idea to the president. The engineer is enterprising and thorough, so he has written up a complete description of the apparatus, obtained estimates of cost, and estimated the quantity that he believes could be sold in a two-year period. He believes that the firm should immediately start the manufacture of several hundred units, as he is positive that the design is complete and that he, personally, could sell them if the sales department cannot be made to do so.

The engineer, in this case, being unusually thorough and analytical, will be given the benefit of the doubt by assuming that his estimates are correct and that his enthusiasm is warranted. This is exceptional, because usually he only has an idea which is not thoroughly worked out. However, after consideration, the president rejects the plan, and sincerely attempts to explain to the engineer the reasons why the project cannot be undertaken profitably at that time.

Some of the reasons that he advances are (1) all departments are fully loaded and will be for another year; (2) the firm has all of the business that it can handle without expansion of facilities and personnel; (3) the sales department is fully occupied with a campaign and can give this no attention; (4) the sales organization is geared to large volume merchandising and would find it difficult to absorb a low volume, high cost, specialized unit; (5) the salesmen have no training in contacting the type of customer that would purchase this equipment and have no contacts with these customers; (6) the design is not complete enough to manufacture and would require considerable additional engineering and drafting man-hours to complete; (7) tooling, processing and cost estimates would require an investment out of proportion to total profit; (8) if it were agreed to overcome all of the above objections and go ahead, it would be over a year before the product would be available, and by that time the market would no longer exist in the same degree; (9 furthermore, there are specialty manufacturers in this field who can design, manufacture and market this product more effectively; (10) and unless a decision is made to go into this particular market and fully cover it competitively, it is unwise to market a single product in the field.

The engineer is disappointed and disillusioned because the president is well known for his progressiveness and willingness to take a chance. He cannot understand the objections because he is certain in his own mind that, if given the opportunity, he, alone, could overcome all of the objections and handle the sales himself, thereby making a profit for his firm that would not otherwise be made.

However, if he is a sensible young man, he finally realizes that his limited experience cannot compare with that of the president, even though he is not completely convinced that the president knows what he is doing. He realizes the president has operated the firm profitably for many years, and has attained excellent working conditions and wages for his employees.

On the other hand, the president, who was once young and inexperienced himself, feels a deep responsibility to his engineer. He has seen this happen many times before and he, himself, has tried ventures such as this previously, with success in some cases, but failure in many others. He is still tempted to take up the young engineer's idea, but finally lets his decision rest and the project is shelved. He knows that he has a problem with his engineer. He does not want him to lose such enthusiasm, but rather to encourage the engineer to propose further ideas and plans for products. However, if he is not careful, the engineer will retire into his own disillusionment and never propose another plan. The engineer, if he is really sensible, will see the common sense of the situation and continue to propose ideas. Nine out of ten of them will probably be rejected, but he cheerfully continues because the particular engineer is sensible and has the good judgment to rely on the experience of his management. To end the story, the years go by and several ideas of the engineer are accepted, one a tremendous success. The engineer is now the president, repeating the same story to his young engineers.

The moral of the story is: Rely on the better judgment and experience of your management and take the disappointments in your stride.

## Conclusion

It is not my intention to repeat a long list of adages about how an engineer can be successful. Rather, I sincerely wish to give the young engineer an explanation of the operation of an industrial organization, and help him in some measure to fit himself into the system where he can accomplish the most—because in so doing he will be the most satisfied. The greatest satisfaction is accomplishment.

It will be of little value to describe in detail the operation and necessity for the various departments in a manufacturing firm; sufficient to state that accounting, inventory control, tool design, processing, purchasing, maintenance, inspection, cost control, sales, personnel, and many other departments are as essential as the engineering, sales, and manufacturing departments. Each has been adopted by experience and found essential. It is necessary for the engineer to realize the value of an organization, and learn that he cannot be an expert in all of these fields. He is an engineer and he must learn enough about the other departments to be able to co-operate with them; but he must leave inventory control, as an example, to someone trained in that field.

The engineers and scientists have the best chance in history to become a more important part of society and obtain the material things of life. Never has there been a more technical age. But they must do their part, learn their jobs well, do good technical work; but, above all, learn the value of good human relations. They must make use of their present advantage for their own happiness, prestige, and success, without harming other less fortunate people in society.

# Beginning a Career in Engineering*

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## Introduction

THE YOUNG MAN who has recently graduated from an engineering school, or is about to graduate, is frequently beset with many questions which his engineering education has failed to answer. Still other questions arise during the early stages of his career. These questions are not so much of a technical nature as they are concerned with the problems of self-management in relation to the field in which the engineer hopes to earn his livelihood.

This paper attempts to answer some of the more common questions on such subjects as "What kind of job should I try to get?" "How should I go about getting it?" "How can I improve my chances of success?" and "What about salary?"

## Choosing a Job

Although the young engineer with little or no experience must approach the problem of choosing a job with a degree of open-mindedness, including a willingness to make his selection from the jobs which are available even though they may not appear to be exactly what he would like to have, the intelligent exercise of whatever degree of choice is permissible is extremely important. Wise or fortunate choice of the first job is a big step in the direction of a successful engineering career.

The most important criterion in the selection of the first job is probably the type of work involved and the opportunities which it offers for learning. Working for a sound and progressive company, location in an area providing pleasant living conditions, the starting pay offered, and opportunities for increased responsibilities and pay are all important, but learning opportunities should be the prime consideration. The first job is seldom the one in which an engineer will spend the majority of his life. He may change to another company providing higher pay and greater opportunities for advancement or located in a more suitable area, but the experience gained in the first job will always remain with him.

By the time of receiving his diploma an engineer has presumably decided, on one basis or another, which branch of engineering he prefers, whether electrical, chemical, mechanical, etc. He may also have selected a field more specifically, such as one of the branches of electrical engineering, perhaps radio engineering, power engineering, or illuminating engineering. In many cases, the young graduate has no further ideas as to preference, whether he would like research, development, production, or sales engineering, for example. Although initial preferences must of course be subject to later revision, a choice should be made in order that the field of endeavor may be that for which the individual is best suited by training and personality, and in which he will therefore probably be best satisfied.

The distinctions between research, development, production engineering, sales engineering, maintenance engineering, etc., have been explained in some detail in several published articles. In general, the engineer who particularly enjoys courses in mathematics and theory and who takes pleasure in new ideas and discoveries is probably well fitted for research or development. The man who enjoys doing something of a more obviously productive nature, such as actually building equipment for his own use, may prefer production engineering. One who has a gregarious nature and gets along well with others, particularly relative strangers, has a good start on a successful career in some field such as sales engineering, in which these abilities and talents play a large part.

The nature and amount of the supervision given the young engineer is of considerable importance in determining how much of value he will learn. Too much supervision is as bad as too little, since too much supervision tends to prevent the engineer from doing much work which is really his own in other than a routine sense. On-the-job learning should ideally be composed of about equal parts of learning by doing and learning from contact with others. Consequently, in selecting his first job the young engineer should ascertain that there is a real need for his engineering talents, but that he will not be required to solve difficult problems single-handed.

For the first job, it is wise to avoid the extremely small organization, employing only one or two engineers, as there is too little opportunity for learning from others. In organizations with perhaps half a dozen or more engineers, it is almost certain that the inexperienced man will have ample opportunity for contact with one or more persons from whom he can learn something of value. In the extremely large organization there will be several men who are authorities in their fields, but the very size of the organization ordinarily limits close contact of the young engineer to a relative few of these experts.

Some young engineers shy away from the very large organizations, feeling that there is danger of becoming lost among the many other engineering employees and that opportunities for advancement may therefore be limited. In general this is not the case, as almost all large engineering groups are subdivided into departments of more easily manageable size, the head of each department being autonomous to at least some degree. Advancement of the engineer occurs within his own department much as it would in a smaller organization.

On the other hand, suspicion is sometimes cast at smaller organizations on the basis that there are fewer jobs available at top levels. Here again, the suspicion is largely unfounded. It is true that the number of top-level jobs is limited, but at the same time the number of persons competing for these jobs is small, so that the individual has about as much chance of advancement in the small organization as in the large one. Even if the man should eventually outgrow the company, being capable of holding a job which is already occupied or does not even exist in that particular organization, he can leave the organization for another one with probable ultimate benefit to himself and his career as the result of the experience he gained in the smaller company.

Many of the larger organizations have training programs for young engineers, the purpose of these training programs being to familiarize the individual with all aspects of the company's business and to give him, in some cases, certain specialized technical or business training which he did not receive during his formal education. Such training programs are of great value to the young engineer.

Smaller companies, as a rule, have no such formal training provisions, but the small size of the organization makes it possible for the individual to become familiar with its over-all operation, including the various technical fields of concern, to a degree which is not possible in large organizations without some type of formal training program.

## Getting the Job

Once one or more positions have been selected as promising in view of the young engineer's desires, the next step is that of actually securing one of them.

Most graduating engineers, particularly those from the larger schools, are offered opportunities for interviews with prospective employers at some time prior to graduation. This is an excellent method of making the initial contact, as the companies doing such interviewing obviously have a need for men of the type to whom interviews are offered. It is a mistake to assume, however, that interviews arranged through school authorities are the only suitable means of establishing contacts with employers.

Direct contact between the engineer and the employer is also a very promising possibility, as many organizations, particularly the smaller ones or those needing only a few new men, do not conduct college interviews. Direct contact is particularly desirable in the case of the man who has more to offer, especially in the form of actual engineering experience, than the average graduate.

Such direct contact should ordinarily be made by means of a letter to the personnel manager, chief engineer, etc., of organiza-

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tions for whom the engineer thinks he might like to work. The letter should preferably be rather brief, stating principally that the writer is interested in the possibility of obtaining a position and describing very briefly what he has to offer in the way of education and experience. Attached to the letter should be a more complete résumé of education, experience, etc. Instructions as to writing such letters of application are included in courses in engineering letter writing and business correspondence, which are available at almost all technical schools.

In any event, the engineer will almost always attend an interview with any employers who are interested in him before he is actually offered a position.

It is probable that no two executives conduct interviews in exactly the same manner and that no two executives look for exactly the same qualities in prospective employees. In general, however, the following qualities are considered important, the order of listing providing at least some indication as to relative importance in the eyes of most executives:

1. Capacity of the engineer to learn and to grow into bigger jobs.
2. Interest in his field.
3. Honesty and personal integrity.
4. Perseverance.
5. Personality.
6. Educational background and experience.
7. Extra-curricular activities while in college.

In addition, the applicant is expected to present a neat personal appearance at the interview. Very few things make such a poor impression on interviewers as the arrival at an interview of an applicant who has neglected to wear a fresh shirt or forgotten to comb his hair. The importance of neat appearance has been emphasized time and again, but a great many applicants apparently fail to pay it any heed.

The applicant should approach the interview with an air of assurance but without cockiness. He should see to it that the interviewer's attention is called to any special qualifications he may have, but should not brag about his accomplishments or attempt to make them seem more important than they actually are. Such subterfuges are readily detected by experienced interviewers and create a poor impression.

It is useless to attempt to hide such undesirable factors as poor grades, for example, as the interviewer who is interested can usually obtain the information he wants through the school authorities. The student with moderately low grades should not assume, however, that he is necessarily at a disadvantage when it comes to getting a job, as many organizations do not attach a great deal of importance to extremely high scholastic rank. Some, in fact, will not hire an engineer with the best grades for certain types of engineering positions because of a fear that the man may not be satisfied with work which does not demand the highest theoretical training and ability.

The man with mediocre grades should probably seek a position in production or sales engineering rather than research or development, as these latter fields require more ability and knowledge in such subjects as mathematics and other theoretical topics. In general, the man with mediocre grades, unless these grades have resulted from some such cause as the necessity for working long hours while attending school, will be neither happy nor successful in research or development even if he should be able to secure a position in these fields.

The engineer with very poor grades is almost always looked upon with considerable suspicion by employers. He will frequently do well to accept any position he is able to get and may, in fact, ultimately decide that he has no bright future as an engineer and should seek another type of work.

Discussion of salary will frequently arise during the first interview. In other cases, it may be left for later correspondence between the applicant and the employer. In any event, it is normal to express a healthy interest in the rate of pay involved, but too much importance should not be attached to it. Most organizations offer similar or identical salaries to all inexperienced engineers, since they generally have little information, other than that provided by educational background, on which to judge the individual.

The opportunity which offers the most in the way of possibilities for learning is usually the best, even though the pay may be a little lower. After a year or two on the job, the engineer will have had the opportunity to demonstrate his abilities to his employers and will almost always find that any initial inequality of salary will have been taken care of adequately.

## Doing the Job

When he arrives to take over his new job, the engineer should resolve to make as good a first impression as possible. It is an ancient but accurate axiom that first impressions are the most lasting. The man who bobbles the first task to which he is assigned makes an impression that will be difficult to overcome, while the person who performs his first duties well can afford to make a few mistakes later without having his supervisors and associates regard him as necessarily stupid. A simple task done well is, of course, not as laudable as a more difficult one done equally well, but it is infinitely better than a simple task done in a mediocre fashion.

Employers frequently expect a new engineering graduate to be a liability for a time, so that the man who makes a good first impression comes as a pleasant surprise.

Of the many pitfalls on the road to engineering success, some of the most serious are lack of perseverance; lack of self-confidence; failure to accept responsibility or, almost equally bad, assuming too much responsibility; failure to keep the ultimate goal of the work in mind; jealousy of fellow employees; and unjustified antagonism toward supervisors or employers.

It has been truly said that brilliant minds easily become bored. Many otherwise capable engineers make an excellent start on each new job, but their interest gradually dies out as it loses its novelty. Perseverance is a very valuable quality in engineering, as in almost all fields of endeavor. A job well begun must be pursued to its end with equal diligence if it is to be of any real value.

Blind perseverance, however, is not enough. Each new job must be approached also with confidence. "If this job can be done, I can do it." The man who doubts his ability to do a job will almost certainly fail. It must be remembered that a supervisor will not assign a job to a man whom he does not consider capable, and that a difficult job is the best type in which to learn and to demonstrate ability.

A question which every engineer should ask himself frequently is "Why is this job being done?" In many cases, the basic answer is that the employer expects to make a profit from the work in some fashion. In other cases, such as in government or other nonprofit establishments, the profit motive is absent, the object being the protection of the country, the advancement of mankind, etc. In any event, the ultimate goal should exert a constant and significant influence on the course of the engineering work.

The engineer may frequently find it necessary to subordinate his own desires to do a technically perfect job to such considerations as time or cost. If this is the case, he should do so willingly, recognizing that it is necessary to the successful attainment of the actual goal of the work.

Continual recognition of the goal is difficult, the tendency being to lose oneself in the day-to-day details of a job. It is worthwhile to stop occasionally in order to reexamine the course of the work to date and to assess its probable future direction. In this way, it may frequently be found that difficulties which seem insurmountable can be overcome by virtue of a new approach which will serve the ultimate purpose equally well.

The matter of accepting responsibility is one which requires careful treatment. Most young engineers tend to accept too little responsibility rather than too much, but there are a few individuals who are willing to take the responsibility for anything, regardless of their ability or authority, and to give orders and suggestions to anyone who appears willing to take them.

Every engineer should familiarize himself with the details of his organization's operation in order to ascertain which functions are properly engineering functions and which belong to other departments. In no case should the engineer assume any responsibility or authority for functions, such as making purchase commitments, for example, which are properly within the jurisdiction of other departments. With regard to engineering functions, it is usually safe to assume responsibility in matters for which one is qualified and which are not known to be the responsibility of others. Supervisors should not be continually pestered for decisions on trivial matters. Except in instances in which an incorrect decision would have serious consequences, supervisors usually prefer that their subordinates do their work with a minimum of close supervision, and every man is, of course, allowed a certain percentage of mistakes.

A healthy attitude toward one's fellow

employees is important. Jealousy and hogging the credit have no place in a well functioning organization. The man who is always first in line when praise is in order is frequently the last to exert himself when there is work to be done, and he fools no one but himself. His associates resent his conduct and his supervisor will quickly find him out. The result may well be that he will fail to receive credit when it is due him, as others may suspect that he is again trying to steal the glory.

The man with a self-deprecating attitude may find that it takes a little longer for his achievements to come to the attention of those in authority, but he will be respected by his associates and will almost always ultimately receive the credit to which he is entitled.

Relations of the engineer with non-engineering employees are extremely important. In the course of his work, an engineer inevitably comes in contact with members of other departments whose training, abilities, and duties differ from his own. A haughty or dictatorial attitude must be avoided in such contacts, as it will result not only in loss of personal prestige but in failure to deal effectively with other departments. When co-operation or assistance from another department is desired, the engineer must be careful to present his needs through the proper channels, not short-circuiting established lines of authority. Once the necessary contact has been established, however, details may be handled on a person-to-person basis between the individuals involved. If the co-operation or service is unsatisfactory, the man responsible should be told first—not his supervisor. A difficult job well done, however, should be called to the attention of the supervisor if the opportunity is available. The person deserving the credit will be appreciative and will make every effort to do equally good work in the future.

In addition to maintaining a healthy attitude toward his fellows, the engineer must be careful not to develop resentment toward his supervisor or employer for injustices he fancies have been done him. If he takes the trouble to discover the facts behind the situation, he will usually find that the injustice was unavoidable and, frequently, that no injustice exists at all. In the event of a real injustice which appears unnecessary, it is still probable that it was not deliberate. In such a case, the matter should be called to the attention of the supervisor, who will almost always be found sympathetic and will do his utmost to have the situation corrected.

The engineer should always keep his supervisor's problems in mind. The supervisor has a large number of subordinates whose welfare he must look after, and he must be concerned with the smooth operation of his department as a whole, even if some inconvenience to individuals may occur in the process.

The man who expects to advance as an engineer must do his job to the best of his ability at all times. The dull, uninteresting tasks must be approached with the same industry which is applied to the more intriguing ones. Engineering is not a job one can leave behind at the end of the day. Overtime work, at home or at the office, is frequently necessary to the success of an endeavor. Competition for top engineering positions is keen, and only the most capable and most industrious achieve a high degree of success.

If advancement seems slow in coming, the engineer should not despair. It may be that a position of greater responsibility is not available immediately, but satisfactory performance, and particularly exceptional performance, is almost always rewarded.

### Supervising Others

Sooner or later, the engineer can expect to be placed in a position where he will supervise other employees. Although this will not occur immediately upon taking his first job in most instances, some understanding of supervisory problems is important to the young engineer if he is to get along well with his own supervisor.

Supervision of others is one of the most difficult tasks for the engineer, possibly because his schooling seldom includes any training aimed specifically in this direction. Perhaps the most important thing to keep in mind is that all of one's associates, superiors, and subordinates are individuals like oneself, each having his own ambitions, likes, dislikes, and peculiarities. The successful supervisor must treat his subordinates accordingly, attempting to discover the particular abilities of each and assigning duties with these abilities in mind.

A common fault among poor supervisors is that they attempt to do too much of the work themselves, leaving only the simple tasks or the uninteresting duties to their subordinates. Such men fail to make the most of the abilities of their assistants.

A supervisor must not be afraid to admit that he is not omniscient. No man is expected to be the top expert on everything which takes place in his department. He is provided with a staff of carefully trained men and is required only to supervise their efforts in the interests of over-all effectiveness.

The supervisor should keep his subordinates informed of significant developments at all times. This tends to prevent the origin and spread of incorrect rumors and makes for better efficiency by placing the necessary information before those who are expected to act in accordance with it.

When praise is due, the supervisor should see that it is given to the persons deserving it and that these persons are aware that their performance has been noticed.

When criticism is in order, it must be carefully administered. Although praise may be given in public, successful criticism must be administered in private to avoid embarrassing the defaulter in front of others. The supervisor must approach the situation with a desire to be helpful rather than merely to castigate. He should attempt to explain the problem to the man at fault, to discover the true reasons for the difficulty, and to make helpful corrective suggestions. Above all, he should not threaten. A man who has been threatened with dismissal may as well be dismissed; he will be of little future use.

### The Question of Pay

Frequently, the young engineer on his first job becomes disturbed because he feels that he is underpaid in comparison with other employees, particularly those having less education. He feels that he has invested several years of study, in addition to a considerable amount of money, in his education and that he is entitled to some compensation in excess of that received by other employees who have had little or no advanced formal education.

However, there are several factors which must be borne in mind for a true evaluation of the situation. In the first place, the engineer cannot expect to recover his investment in a short period of time from his first employer. Instead, returns will be received over the entire course of his career in the form of greater earnings in later years, a position demanding greater respect, and a job which gives him a large measure of satisfaction.

For the first several months, the young engineer is likely to be more of a liability than an asset, so that his salary during this time represents an additional investment in him on the part of his employer. In addition, the economics of business dictate that each employee must be paid in accordance with his worth to the organization. A good machinist, tool maker, or even a truck driver cannot be replaced by the average engineer at any price, and these men are frequently just as important to the organization as is the engineer.

Most organizations have established times for granting pay increases to deserving employees. The young engineer can expect, if he does his work satisfactorily, to receive periodic increases amounting to from one or two hundred to as much as four or five hundred dollars per year during the initial years of his career. After this period, he is on his own, receiving increases in both salary and responsibilities strictly on his own merits.

The man who feels that he is underpaid, after considering matters carefully, may take the subject up with his supervisor a month or two before any increases are due. He will usually find that his supervisor is aware of the injustice and that arrangements have already been made to correct it. At any rate, the supervisor will almost always be willing to listen to reasonable requests for salary increases if they are presented at such a time as to fit in with the organization's policies in such matters.

The engineer must not expect to grow rich in the engineering field. It is not a notably high-paying one, and the man whose principal interest is money would do well to cast his lot elsewhere.

# An Experimental Large-Screen Television Projector*

P. MANDEL†, ASSOCIATE, IRE

*Summary*—**A television projector using a high-voltage cathode-ray tube is discussed. The modulation circuits, the projector system, and the directive projecting screen are described in detail.**

## Introduction

THE PROBLEM of reproducing large television pictures covering a surface of about 10 square meters or more, with the same brightness as is usual in the case of ordinary motion pictures, has not been satisfactorily solved up to the present. This has been due to the economic necessity of first producing a highly developed field-tested home receiver; the necessity of developing a large-screen television projector being less urgent. However, there can be no doubt concerning the advantages of a simple and satisfactory television projector to the motion picture industry, to medical and technical institutions, and to educational organizations. With this in mind, research work was undertaken by the author and his coworkers in the Montrouge laboratories of the Compagnie des Compteurs several years ago with the purpose of obtaining a satisfactory solution to the projector problem.

As a result of this work, some questions could be solved in a satisfactory manner, while others are yet waiting for a more acceptable solution. The author feels, however, that some parts of the experimental large-screen projector would be of certain interest to the workers in the same field, and that the publication of the results obtained would contribute to the progress of the television art.

## Choice of the System

It was felt at the beginning of the work that the use of a cathode-ray tube in the classical, or eventually in an improved, form would lead to a satisfactory solution, with the exception that, in the case of extremely large screens, the Eidophore projector would be better able to produce the necessary luminous flux. Consequently, the apparatus comprises the high-frequency picture- and sound-receiver, the sync-separator circuits, the projector, including the modulation, deflection, and various auxiliary circuits, the high-voltage generator, and the control desk, as shown in Fig. 1.

Two identical units form the complete projector so that, in the case of failure of any part of one unit, the second unit can be immediately switched on, thereby assuring continuity of projection.

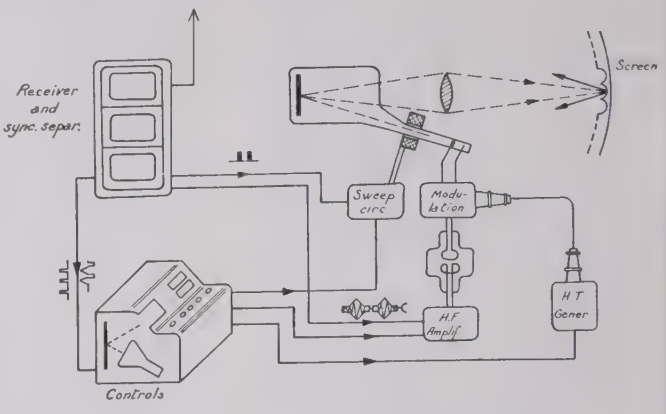


Fig. 1

## The Video Channel

The apparatus is designed for the reception of the French low definition standard, i.e., 450 lines composing fifty fields and twenty-five complete pictures per second, and the picture being transmitted with both sidebands on the carrier of 46 Mc, with the accompanying sound on 42 Mc.

The high-frequency section of the video receiver is of the straight amplifier type, using vestigial sideband transmission, as represented by Fig. 2.

In order to obtain the highest possible signal-to-noise level, and in order not to deteriorate the background in certain cases by the spurious components generated by the harmonics of the carrier and of the local oscillator, no use was made of frequency changing. The

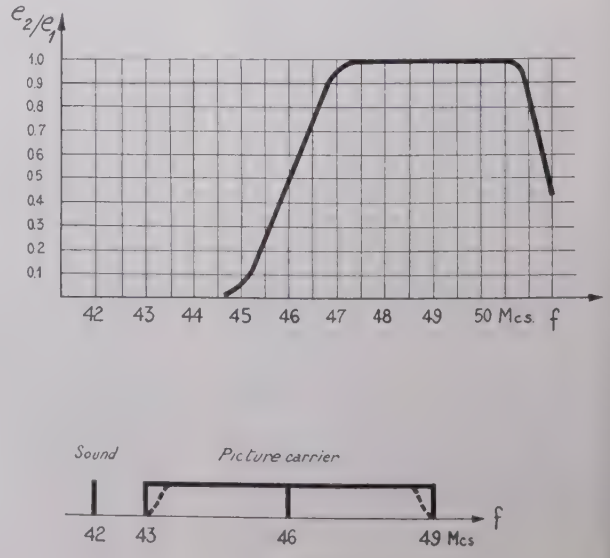


Fig. 2

* Decimal classification: R583.5. Original manuscript received by the Institute, December 17, 1948.

† Radio-Industrie, Paris, France.

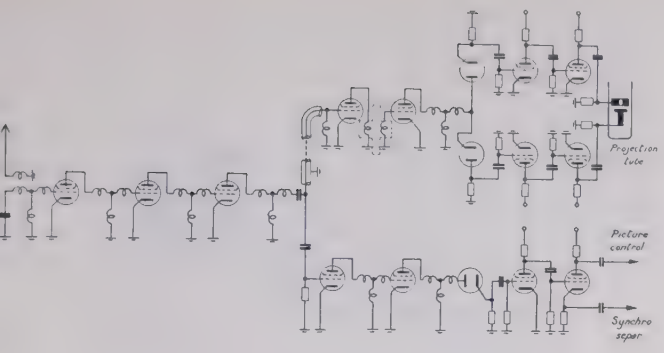


Fig. 3

general layout of the receiver is shown in Fig. 3. The receiver feeds, besides the projector, the control kinescope, and the sync separator.

The plate of the projection tube being at ground potential for reasons explained later, the introduction of the modulation signal on the tube, the cathode of which has a potential of some minus 80 kv, had to be made in a somewhat unorthodox manner. The video signal is transmitted by a high-frequency filter of a particular mechanical construction, as represented by Fig. 4.

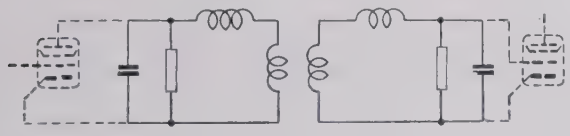

Fig. 4

The inductances of the critically coupled high-frequency transformer are disposed in the interior of an evacuated container. Short sections of a co-axial cable connect the inductances to the plate of the preceding, and to the grid of the following amplifier tube, whose output and input capacitances, shunted by resistors of convenient value, tune the filer. The form of the container and the distance between the inductances are chosen to support the potential difference of 80 kv with a sufficient margin of safety.

A slightly different coupling device, shown in Fig. 5, could be successfully used for the transmission of carriers with a bandwidth of 15 to 20 Mc. It consists of a half-wave section of a parallel high-frequency line, interrupted in the middle by a pair of small capacitors, whose separation is large enough to support the dc potential difference of 80 kv, once the device has been

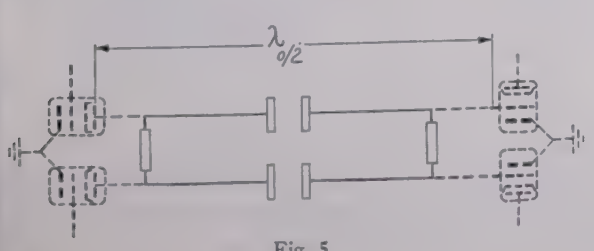


Fig. 5

immersed in oil, or has been disposed in an evacuated container. The device is tuned by the output and input capacitances of the amplifier tubes.

In order to obtain the relatively high voltage (about 250 volts peak to peak) necessary for the full modulation of the projection tube without perceptible nonlinear distortion, a push-pull class-B arrangement was chosen, as shown in Fig. 6.

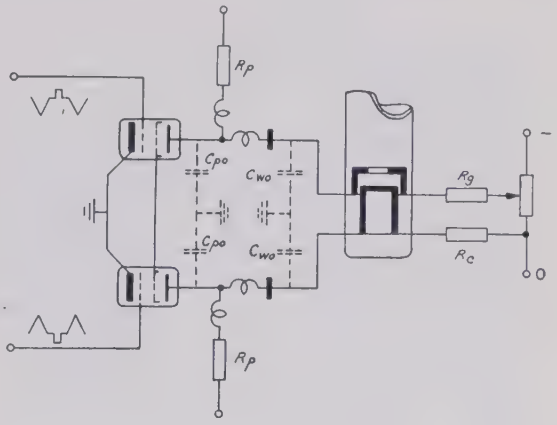


Fig. 6

By this means, not only may the admissible plate resistor ($R_p$) be doubled, but the power stage of the amplifier may be fully utilized from cutoff with a full grid swing without any appreciable distortion caused by the curvature of the tube characteristic. The two signals in opposition are obtained by two separate video detectors fed by the last stage of the high-frequency amplifier. The frequency characteristic of the video section is shown in Fig. 7.

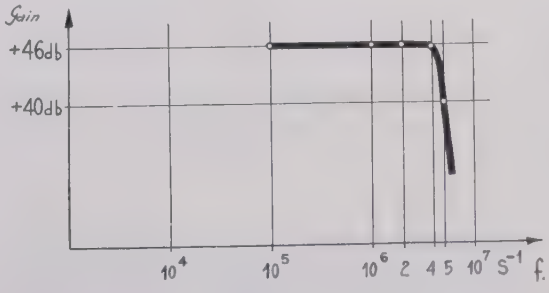


Fig. 7

*The Sync Separator*

It is a well-recognized fact that the advantage of interlaced scanning can not be fully appreciated without a correct interlacing of the two frames on the screen. It was recognized that in order to obtain this result under practically every conceivable circumstance, it is necessary that the whole system possess the following properties:

(a) The vertical sync-signal must have exactly the same shape after each field repetition. The foregoing concerns the form, the level, and the composition of the signal.

(b) After separation there should be absolutely no traces of horizontal sync pulses in the signal intended for vertical synchronizing.

(c) After separation there should be absolutely no traces of vertical sync pulses in the signal intended for horizontal synchronizing.

(d) There should not be the slightest interaction between the horizontal and vertical scanning generators.

(e) The vertical deflection must be constant within $2°/_{oo}$ of the total sweep amplitude.

(f) To insure the correct functioning of the sync separator, no manual adjustments are allowed. The sync separator should deliver synchronizing pulses absolutely identical in form and in amplitude, if the input of the receiver is superior to 500 $\mu$v, and inferior to 500 mv, regardless of the content of the picture. While (a) must be satisfied by the pickup equipment, (b) to (f) must be met by the receiving apparatus. Fig. 8 represents schematically the circuits used in the sync separator.

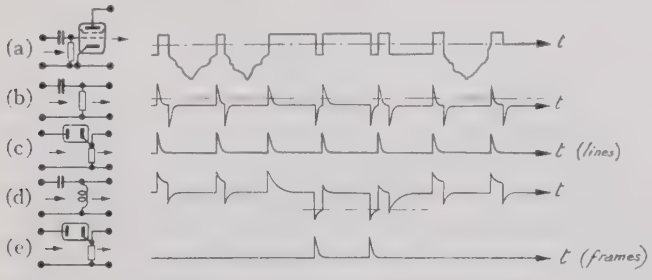


Fig. 8

The inverted video output is applied to the automatically biased grid of a high-slope pentode having a cutoff of only a few volts. In the case where the amplitude of the sync pulses is greater than the cutoff voltage, the output of the stage is independent of the amplitude of the input, and consists of the sync pulses as represented by the portion above the axis in Fig. 8(a). A differentiation by a very short time constant 8(b), followed by a preset clipping 8(c), permits the extraction of the horizontal sync pulses entirely free from any trace of the vertical sync pulses. On the other hand, the composed sync signal 8(a) is differentiated by a longer time constant 8(d), and is transformed after a preset clipping into a vertical sync signal 8(e), without any component possessing the line frequency.

*The Projector Tube and its Auxiliary Circuits*

Preliminary calculations concerning the size of the crossover, the obtainable current density in the spot, and the mutual repulsion of the electrons in the beam indicated that the necessary luminous flux can be obtained by increasing the final velocity of the electrons in the beam to very high values, say, up to 80 kv.

Experimental evidence indicated that, for a given type of electron gun, for a given number of lines, and for a given size picture, the highest beam current compatible with the resolution was, within very large limits, proportional to the total accelerating potential.

This property is well represented by Fig. 9, indicating the highest admissible beam current as a fnnction of the final accelerating voltage for a typical electron gun as used in a projection tube intended to be used for a resolution of 450 lines with a spot diameter on the order of 0.25 mm (0.01 inch).

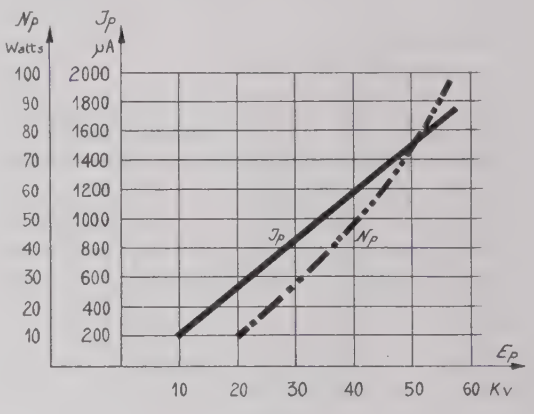


Fig. 9

By utilizing high accelerating voltages, it was necessary to put the last anode and the luminescent screen at ground potential in order to avoid excessive dielectric strain on the neck of the tube, and in order to increase considerably the spark-over distance between plate and cathode connections, as represented by Fig. 10.

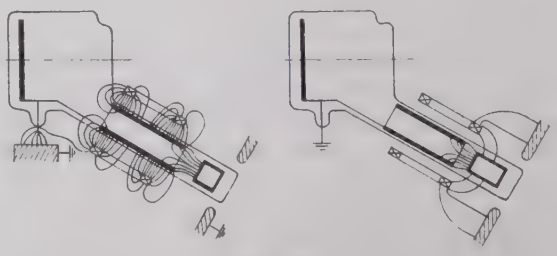

Fig. 10

The greater safety of the equipment seems to the author important enough to justify the somewhat unusual modulating apparatus as described below.

Fig. 11 is a picture of a typical projection tube. The principal characteristics are:

Admissible final accelerating voltage: 80 kv
Mean beam current (450 lines): 500 $\mu$amps
Necessary peak-to-peak modulation: 250 volts max
Focusing and deflection: magnetic

The efficiency of the yellowish-colored luminescen screen, which can be cooled by water or by air, can attain the value of 4 candles per watt.

Research work is going on to obtain white-colored light and eventually higher luminous efficiency of the fluorescent screen.

Fig. 11

Keystone correction and vertical proportionality are obtained in a similar way to the case of iconoscopes, both tubes having substantially the same shape.

Owing to the fact that the length of the beam varies noticeably during the scanning of a complete field, the focus of the spot has to be automatically maintained during the whole sweep period. This is done by the superposition of conveniently shaped synchronous currents on the mean current flowing through the focusing coil. To obtain the greatest stability for this device, the necessary form of the focusing current is produced by the use of appropriated electric networks, excluding the curved parts of tube characteristics which are more subject to slow but inevitable variations.

The fluorescent screen is, for obvious optical reasons, plane. The resulting serious pin-cushion distortion of the scanned picture is compensated by conveniently formed constant magnetic field, generated by compensating coils arranged in a symmetrical manner in the immediate vicinity of the fluorescent screen.

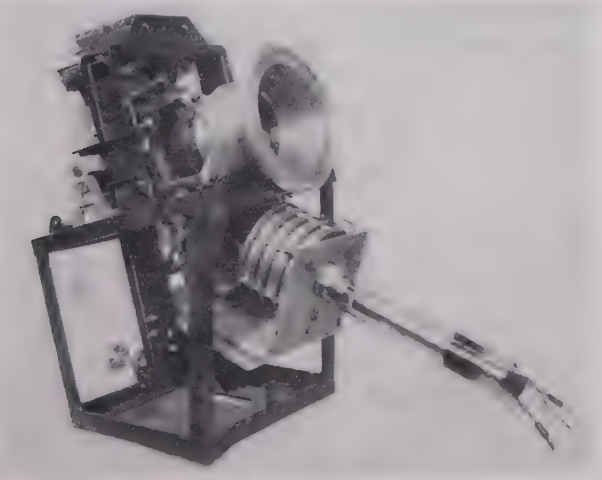

Fig. 12

Fig. 12 represents the physical aspect of the projector head, including the tube, the deflecting and concentration coils, the pincushion compensation, and the $f=1.9$, $f=200$ mm, coated projection lens.

Fig. 13 represents the cross section of the projector, showing from left to the right: the 50-cps power transformer for the video amplifier, the video amplifier, with the high-frequency coupling, the projector head, and the scanning power stages.

The screening necessary to absorb the X rays generated by the tube has been removed in order to make the head of the projector visible.

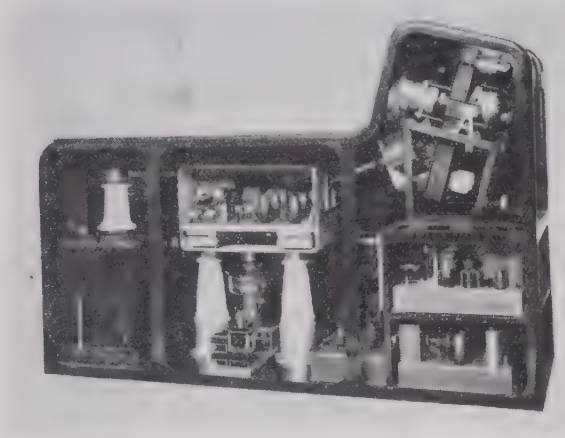

Fig. 13

## Switching on, Control and Operation

The gradual switching on of the apparatus is automatically assured by cascaded relays. In case of failure of power, the apparatus is automatically switched off, and if desired, switched on again, after the return of the power. Voltage can not be applied to the projector tube if one of the scanning generators fails.

The controls for contrast, brightness, focus, picture-height and width, the eliptically swept control oscillographs for modulation depth and sync separation, and a 15-inch control viewing tube are included in the twin monitor desk, as represented by Figs. 14 and 15.

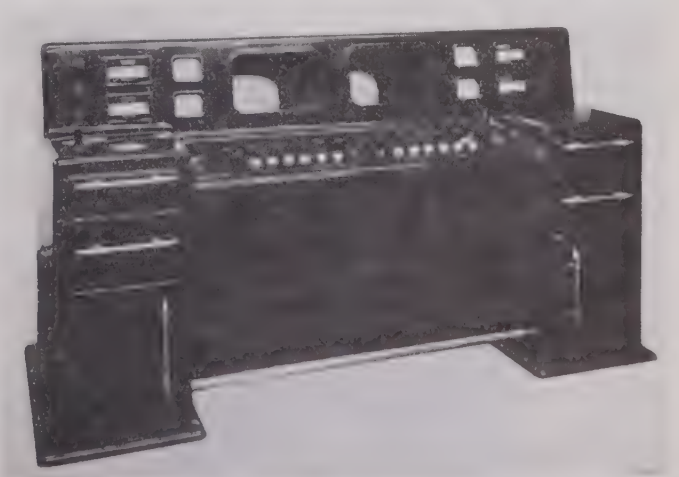

Fig. 14

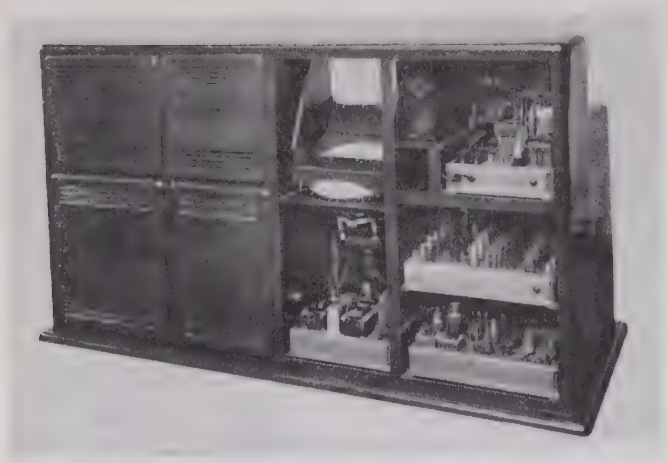

Fig. 15

*The Projection Screen*

Well-known economical conditions did not permit the use of the Schmidt type optical system in the place of the more conservative refractive lens system, which accepts only a few per cent of the total luminous flux issued by the luminescent screen. For this reason the use of a special projecting screen with a controlled directivity was decided upon during the development work.

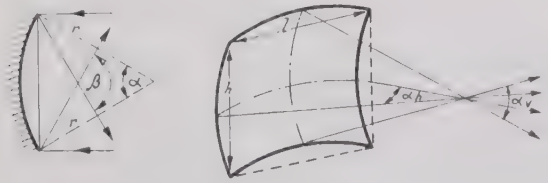


Fig. 16

The use of directional screens for photographic or projection work is by no means new. The realization of a directive screen having large dimensions, however, presents considerable difficulties. The inventiveness of our colleague, I. Saget, made it possible for us to undertake the construction of such a device.

The fundamental element of the screen is the spherical mirror. By the independent choice of the central angle in the horizontal and in the vertical plane, i.e., by the corresponding choice of $r$, $l$, and $h$, it is possible to control the aperture angles $\alpha_h$ and $\alpha_v$ by which a normally parallel incident beam is reflected. (Fig. 16).

Aperture angles were chosen for the screen intended to be used in medium-sized projection theatres, $\alpha_h = 70°$ and $\alpha_v = 36°$. The dimensions of the individual spherical mirrors, whose surfaces are considerably smaller than the size of one picture element are: $r = 3.15$ mm, $l = 2$ mm, $h = 1$ mm. The elementary screen consists of two hundred elementary mirrors stamped together in a highly polished aluminum sheet of 0.05 mm thickness

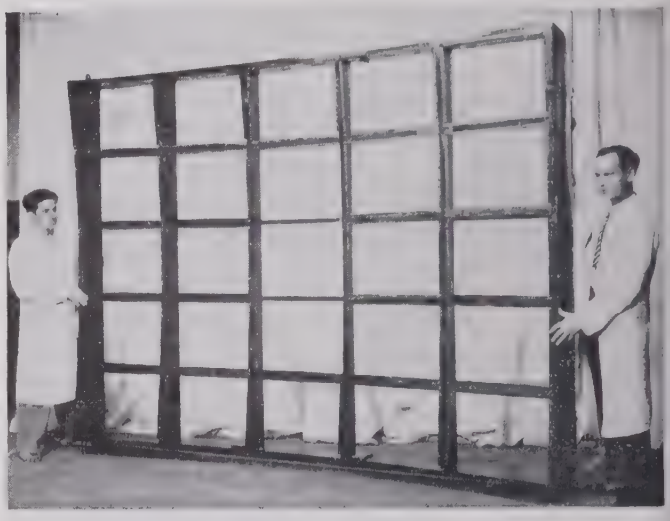

Fig. 18

(Fig. 17). About 15,000 of these elements are fixed in quincun on metallic supports held together by a wooden framework. (Fig. 18).

The dimensions of the projected picture are $3 \times 2.25$ meters. The screen itself has a radius of curvature of 9 meters in order to compensate for the divergence of

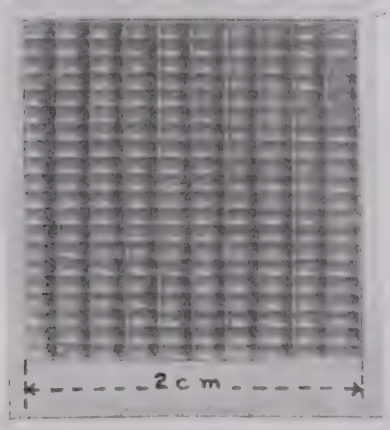


Fig. 17

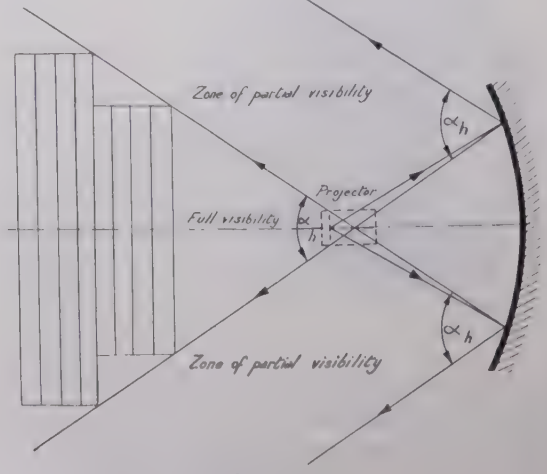


Fig. 19

the luminous beam issued by the projector, situated at a distance of 4.50 meters from the screen (Fig. 19). The measured gain of brilliance against a screen whose diffusion follows the cosine law is 4.25, in good agreement with the theoretical value.

In spite of the careful control of the different phases of the manufacturing process, the screen in its actual form is not wholly satisfactory. Owing to small irregularities resulting in minute local variations of the apparent screen brightness, the finest picture details are lost, giving the picture an undesirable granular aspect. Research work is being continued to improve this undesired effect.

### Acknowledgments

The author is deeply indebted to all his coworkers, and mainly to P. Thomas, of the Compagnie des Compteurs Laboratories, and to I. Saget, whose hearty collaboration made it possible to attain the results described in this publication.

# An Analogue Computer for the Solution of Linear Simultaneous Equations*

ROBERT M. WALKER†, SENIOR MEMBER, IRE

*Summary*—**Linear simultaneous equations occur frequently in science and in engineering. Their solution by numerical methods is straightforward, but the amount of work required increases rapidly with the number of unknowns. A device is described for the solution of systems of linear simultaneous equations with not more than twelve unknowns. It is an electrical analogue computer which accepts the problem information in digital form from a set of punched cards. This facilitates the preparation, checking, and insertion of the input data and greatly reduces some of the usual liabilities of an analogue device. No special preparation of the problem is required, other than a simple one of scaling the coefficients. Solutions of well-determined problems are easily and rapidly attained and may be refined to any desired accuracy by a simple iteration procedure.**

## I. Statement of the Problem

THE SIMPLEST case of linear simultaneous equations is that of two equations with two unknowns. For example

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + b_1 &= 0 \\ a_{21}x_1 + a_{22}x_2 + b_2 &= 0. \end{aligned} \tag{1a}$$

Such a case is very simply solved by any one of several computing methods. But the work required for solution increases rapidly with the number of the unknowns.

The general case with $n$ unknowns may be represented by writing the $i^{\text{th}}$ equation of the set of $n$ equations as follows

$$\sum_{j=1}^{j=n} a_{ij}x_j + b_i = 0. \tag{1b}$$

* Decimal classification: 621.375.2. Original manuscript received by the Institute, April 18, 1949; revised manuscript received, July 21, 1949. Presented, 1949 IRE National Convention, New York, N. Y., March 8, 1949.

† Watson Scientific Computing Laboratory, New York, N. Y.

## II. The Electrical Analogue

The device to be described solves a set of up to 12 equations (i.e., $n \leqq 12$) by means of an electrical circuit analogue. In setting up this analogue for 12 equations one requires 12 variables ($x_j$), 12 coefficients of each variable (making 144 of these $a_{ij}$ coefficients), and the 12 constant terms, $b_i$.

The 12 variables are represented by 12 individually adjustable voltages, the magnitude and sign of each being controlled by the operator. The coefficients are three-digit decimal type voltage dividers which can be set for an output of from $-0.999$ to $+0.999$ times the input. (The method of obtaining the negative sign for a coefficient will be described later.) The constant terms ($b_i$) are obtained by feeding 12 more of these same decimal type voltage dividers from an additional (13th) voltage source. Addition of the terms in an equation is obtained by adding the voltage outputs of these dividers in a resistive network. A block diagram is shown in Fig. 1.

Since the values of the $a_{ij}$'s and the $b_i$'s must all lie in the range from $-0.999$ to $+0.999$ for insertion into the machine, in general it will be necessary to prepare the problem by multiplying each equation through by a suitable constant so that the largest $a_{ij}$ or the $b_i$ in that equation has an absolute value of less than unity. Other types of transformations may be used if desired.

It is also necessary to make another transformation so that a finite range of voltage variation can represent an unlimited range of the unknowns. The transformed unknowns are designated as $X_j$ and are related to $x_j$ by a factor such that

$$x_j = \frac{X_j}{k}, \quad \text{where} \quad k \leqq 1, \; X_j^2 \leqq 1. \tag{2}$$

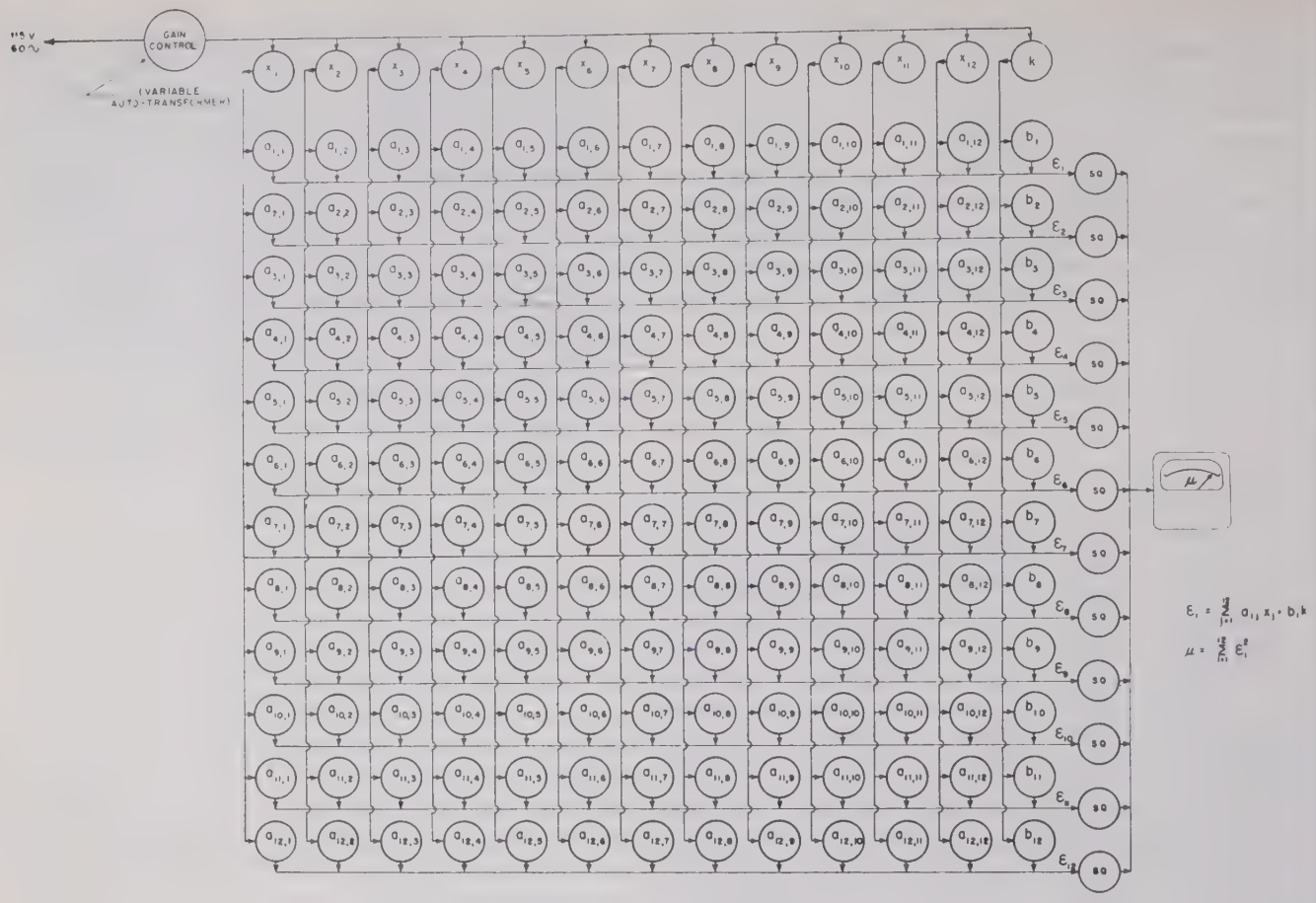


Fig. 1—Linear simultaneous equation solver.

Substituting this in the original set of equations gives

$$\sum_{j=1}^{j=n} a_{ij}X_j + b_i k = 0. \tag{3}$$

It will be seen that $k$ corresponds to the voltage source for the constant terms and that by making it adjustable it becomes a controllable scale factor for the unknowns. This scale factor may be changed as required during the progress of the solution.

Having thus set up the electrical analogue of a system of equations, when one sets in the proper voltages for the $X_j$'s and the $k$ corresponding to the correct solution of the problem, the voltage output will be zero for each of the equations. But until these correct values are obtained an error voltage does exist, in general, which for the $i^{th}$ equation we designate as $\epsilon_i$. The operator is furnished with information (in the form of a single meter reading) so that he can make adjustments leading to the reduction of all $\epsilon_i$'s toward zero. This process is similar to that of balancing a bridge.

## III. The Analogue of $X_j$ and $k$

Thirteen identical transmitter units feed out the 12 $X_j$ voltages and the $k$ voltage. These are schematically shown in Fig. 2. This unit takes the 60 cps voltage from the common supply bus, and provides a low-impedance balanced-output voltage of variable amplitude and sign. The voltage of the supply bus is adjustable from 0 to 120 volts by means of a variable autotransformer, to control sensitivity during the adjustment process. The reason for the division of the output

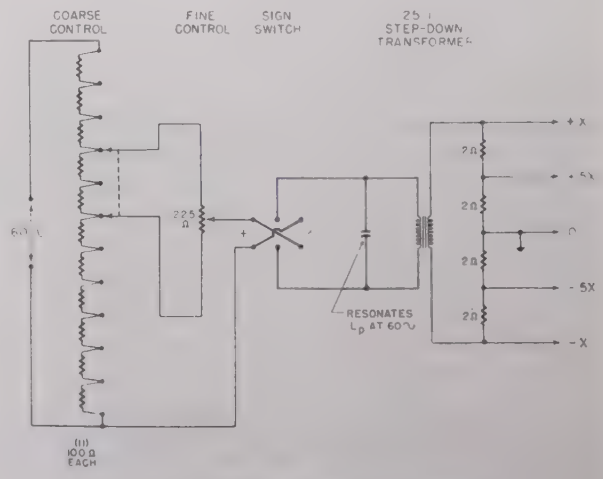


Fig. 2—Transmitter unit for 1 variable.

into four equal parts balanced with respect to ground will appear in connection with the coefficients. These four parts are adjusted to equality within better than 0.05 per cent.

For several reasons, it seems desirable to use ac for the voltage sources of this machine. First, because of the ease of obtaining a large amplification of the equation errors; second, because of the possibility of using transformers to go from unbalanced attenuators to balanced loads; third, because the commercial 60-cps power is economically available. There are consequent disadvantages to the use of ac. Care must be taken to keep phase shifts within narrow limits and, even with such control, special means are required in the indicating device to reject any quadrature components so that they do not obscure the balance indication.

## IV. The Analogue of $a_{ij}$ and $b_i$

The 156 coefficient networks (144 $a_{ij}$'s and 12 $b_i$'s) are all identical. Each is schematical as shown in Fig. 3. The horizontal busses are the output from one of the transmitter units. The three-digit nature of the device is evident from the formula shown.

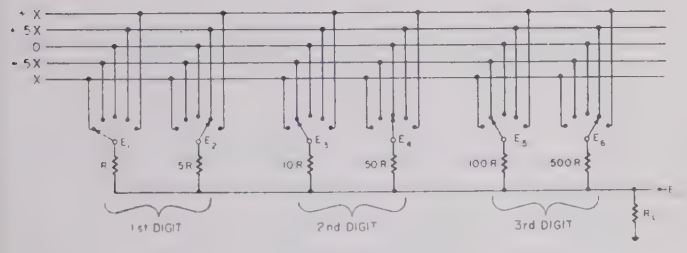


Fig. 3—Coefficient network (1 of 156)

$$E_L = \frac{(E_1 + 0.2E_2) + 0.1(E_3 + 0.2E_4) + 0.01(E_5 + 0.2E_6)}{K}$$

where

$$K = 1.332 + \frac{R}{R_L}$$

Since the voltages $E_1$ to $E_6$ can each have any one of 5 discrete values, it would be possible to have $5^6$ different switch combinations. However, for the first decimal digit only, the 19 combinations of $E_1$ and $E_2$ are used which give from $-0.9X$ to $+0.9X$. These are listed in Table I.

The same combinations are used for the second decimal digit ($E_3$ and $E_4$) and for the third digit ($E_5$ and $E_6$), but with the additional restriction that the second and third digits always have the same sign as the first digit. Thus only 1,998 combinations are actually used to represent values from $-0.999X$ to $+0.999X$.

The accuracy of the coefficient voltage dividers is better than $\pm 0.1$ per cent. The lowest value resistor $R$ of each coefficient is specified to $\pm 0.05$ per cent, the $5R$ value to $\pm 0.25$ per cent, the $10R$ to $\pm 0.5$ per cent, the $50R$ to $\pm 2.5$ per cent, the $100R$ to $\pm 5$ per cent, and the $500R$ to $\pm 20$ per cent. The three lowest values of resistors are precision wire-wound, and the three higher are a composition type.

TABLE I

| $E_1$ | $E_2$ | $E_1+0.2E_2$ |
|---|---|---|
| $-X$ | $+0.5X$ | $-0.9X$ |
| $-X$ | $+X$ | $-0.8X$ |
| $-0.5X$ | $-X$ | $-0.7X$ |
| $-0.5X$ | $-0.5X$ | $-0.6X$ |
| $-0.5X$ | 0 | $-0.5X$ |
| $-0.5X$ | $+0.5X$ | $-0.4X$ |
| $-0.5X$ | $+X$ | $-0.3X$ |
| 0 | $-X$ | $-0.2X$ |
| 0 | $-0.5X$ | $-0.1X$ |
| 0 | 0 | 0 |
| 0 | $+0.5X$ | $+0.1X$ |
| 0 | $+X$ | $+0.2X$ |
| $+0.5X$ | $-X$ | $+0.3X$ |
| $+0.5X$ | $-0.5X$ | $+0.4X$ |
| $+0.5X$ | 0 | $+0.5X$ |
| $+0.5X$ | $+0.5X$ | $+0.6X$ |
| $+0.5X$ | $+X$ | $+0.7X$ |
| $+X$ | $-X$ | $+0.8X$ |
| $+X$ | $-0.5X$ | $+0.9X$ |

The switching is accomplished by making contacts through holes in a punched card, in a card-controlled switching device. Fig. 4 shows the card in place preparatory to closing the reader. The spring-driven pins in the upper plate make contact through the holes punched in the card to switch the coefficient resistors to the appropriate voltage busses. The coding representing a digit ($-9$ to $+9$) is punched in a single column of the card, one punch in one of the upper five positions and another in one of the lower five. Successive columns represent the successive digits of a coefficient, and 36 columns are available on each card to accept the 12 three-digit coefficients of each variable. Thirteen cards are used in all, twelve for the coefficients of the twelve unknowns, and a thirteenth for the constant terms.

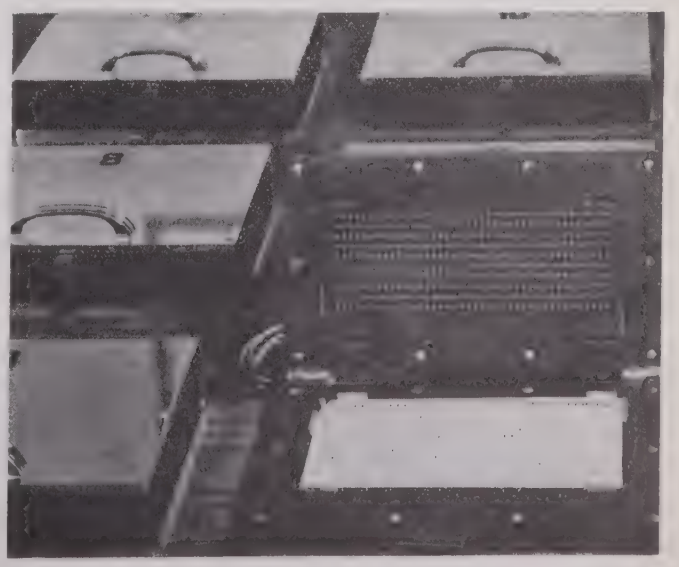

Fig. 4—Card reader open with coefficient card inserted.

Fig. 5 shows the appearance of one of the coefficient cards. For purposes of illustration, the punching has

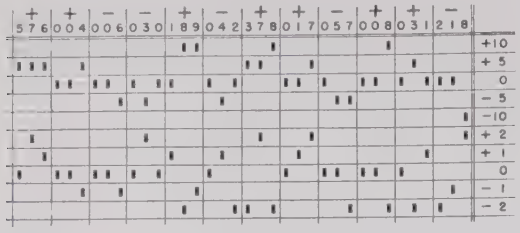


Fig. 5—Sample coefficient card with interpretation of punching.

been interpreted at the side and the top. This double-punch coding is done by a special keyboard attachment to the standard punch. The operator has only to press a digit key and the proper two holes are punched in that column.

The use of punched cards for the insertion of problem data into the machine has several important advantages over the use of switches or potentiometers. It allows the preparation of a new problem while the machine is in use for a previous problem, thorough checking of the data (by duplicate punching and comparison), easy permutation of variables as a check procedure, and the filing of a problem for subsequent reinsertion (as for iteration).

## V. The Summation of Terms

The summing of voltage outputs from the appropriate coefficient networks to form the first equation is accomplished by connecting the outputs of all 13 coefficients associated with this equation ($a_{1,1}$, $a_{1,2}$, $\cdots$, $a_{1,12}$, $b_1$) to a common output bus. This means that the load resistor $R_L$ for the coefficient network shown in Fig. 3 is the impedance seen looking back into 12 other identical networks in parallel. Therefore, $R/R_L=12\times1.332$ and $K=13\times1.332$.

The other 11 equations are summed in the same manner.

## VI. Method of Solution

In order that that operator can adjust the variables to satisfy the conditions of the problem and thus obtain a null of voltage for each equation, he must be given an indication which will tell him in what direction to proceed. When the conditions of the problem are not satisfied, there will be a residual error which for the $i^{th}$ equation is

$$\epsilon_i = \sum_{j=1}^{j=n} a_{ij}X_j + b_ik \tag{4}$$

It is beyond the scope of this paper to discuss the mathematical proof, but it has been shown that if one sets up the quantity

$$\mu = \sum_{i=1}^{i=n} \epsilon_i^2 \tag{5}$$

and adjusts the variables in a cyclic manner so as to reduce continuously the quantity $\mu$, that $\mu$ will converge toward zero, which, of course, only occurs when all the $\epsilon_i$'s are zero.[1]

To carry this process out for this machine each of the $\epsilon_i$'s is electrically squared and the outputs added. This is not as simple as it might seem since the electrical voltages representing the $X_j$'s are really complex, that is, they are not, in general, exactly in phase with the voltage representing $k$, but may have relative phase angles of the order $\pm1°$. Considering the $k$ transmitter as the reference phase, the situation is as follows:

The output voltage of the $i^{th}$ equation is

$$\sum_{j=1}^{j=n} a_{ij}X_j \cos(\omega t + \theta_j) + b_ik \cos \omega t, \tag{6a}$$

or

$$\left(\sum_{j=1}^{j=n} a_{ij}X_j \cos\theta_j + b_ik\right)\cos\omega t - \left(\sum_{j=1}^{j=n} a_{ij}X_j \sin\theta_j\right)\sin\omega t. \tag{6b}$$

For values of $|\theta_j| \leqq 1°$, $X_j \cos\theta_j \cong X_j$, and

$$\epsilon_i = \sum_{j=1}^{j=n} a_{ij}X_j + b_ik \cong \sum_{j=1}^{j=n} a_{ij}X_j \cos\theta_j + b_ik. \tag{6c}$$

This equation error voltage is seen to contain a cosine term whose coefficient (or amplitude) is approximately proportional to $\epsilon_i$, and also an undesired sine term. The amplitude of the cosine voltage term can be obtained by periodically sampling the output voltage at the times when $\cos\omega t$ is $\pm1$ and $\sin\omega t$ is zero. In practice, it is not necessary to remove completely the quadrature component (sine term) and what is done is to observe the output voltage for a short period each half-cycle when the cosine is large and the sine small; i.e., at the crests of the reference wave.

For the final balancing of a set of equations, it is necessary to be able to observe the presence of $\epsilon_i$'s as small as 0.001 which for this machine will mean voltages of

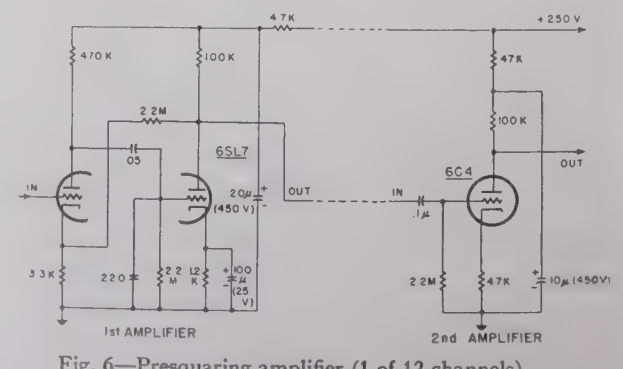


Fig. 6—Presquaring amplifier (1 of 12 channels).

[1] See reference 2 of the bibliography.

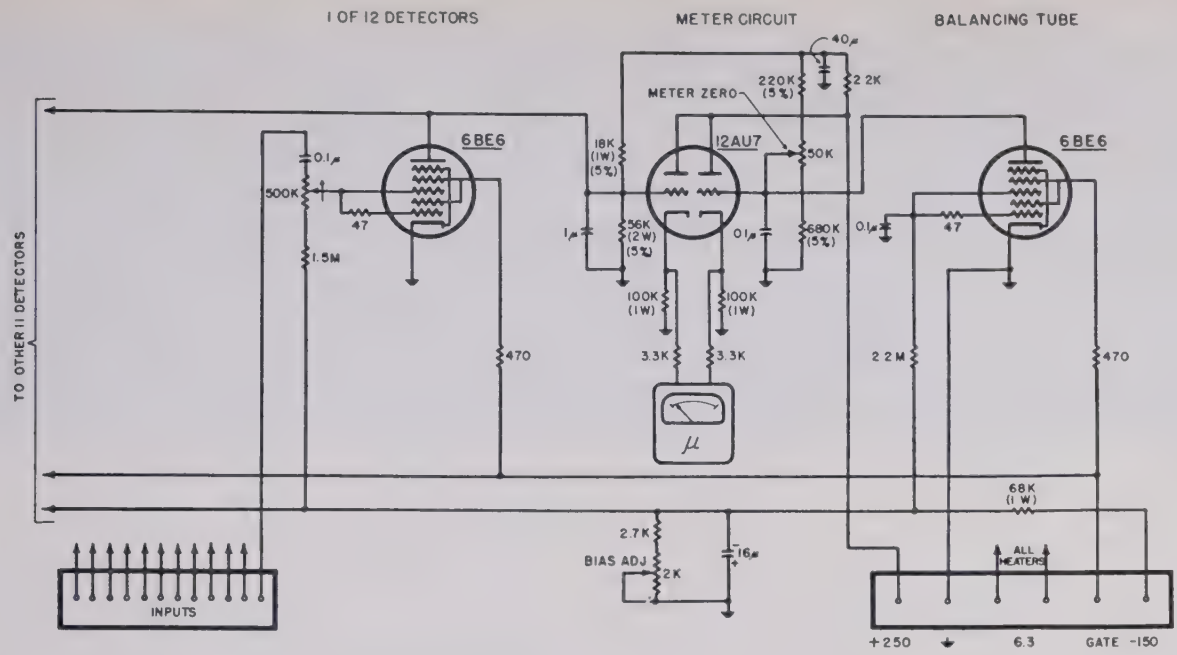


Fig. 7—Square-law detector and indicator circuit.

about 0.1 millivolt. Therefore, the output of each equation bus is fed into a 3-stage amplifier having a voltage gain of 3,000. One of these amplifier channels is shown schematically in Fig. 6. The output of each one of these amplifiers is then fed into a square-law detector. These detectors are pentagrid converters (6BE6) with the input applied to both the first and third grids to increase the square term. The tube is biased to virtual cutoff. Screen-grid gating is applied so that the tube is turned on only in the intervals when the cosine term of the input signal is large and the sine term is small. The dc increment of plate current is approximately proportional to the square of the input voltage, and by allowing all the detector plate currents to flow through a common load resistor, the drop in this resistor is a measure of the sum of the squares of all the $\epsilon_i$'s. A differential vacuum-tube voltmeter is used to display this quantity, which is proportional to $\mu$. Fig. 7 is a schematic of the detector and indicator unit.

The screen-grid gating wave form for the 6BE6's is

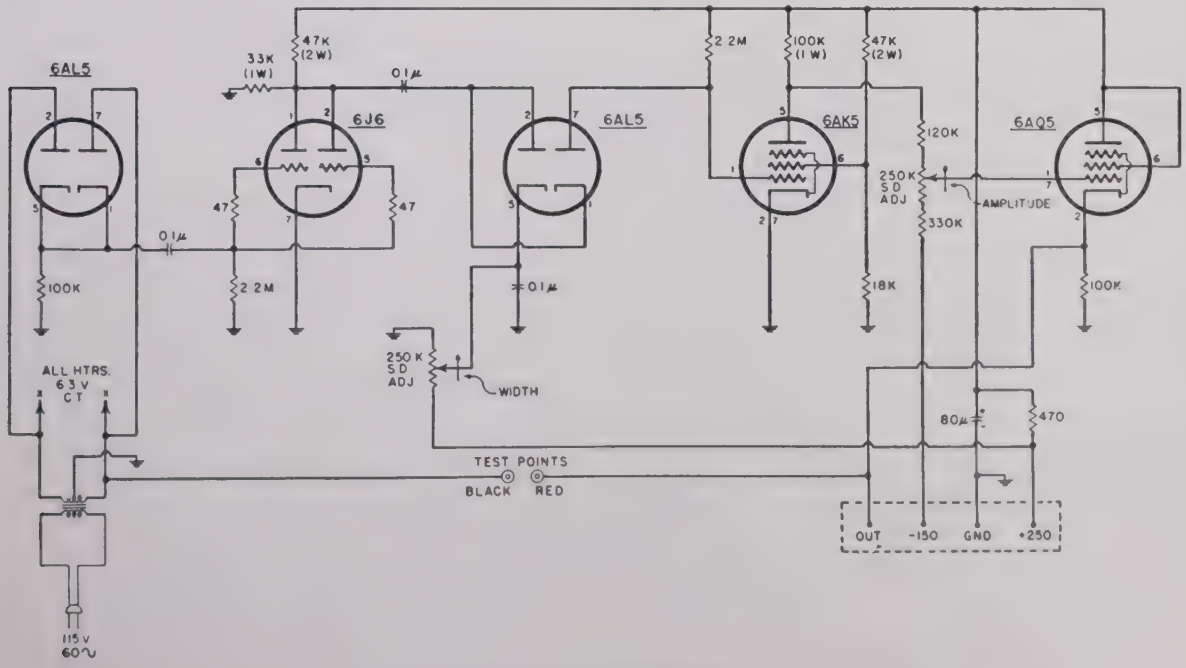


Fig. 8—120-cps gate generator unit.

obtained by full-wave rectification of the 60 cps, followed by clipping and squaring. The circuit of this gating unit is shown in Fig. 8. The output, which is applied to the screens of the 6BE6 detectors, is a 90-volt rectangular-shaped pulse occurring 120 times per second (symmetric about the positive and negative crests of the 60-cps sine wave). The time duration of each pulse is about 1.5 milliseconds.

## VII. Read-Out Method

When all the variables have been adjusted to satisfy the conditions of the problem (as indicated by a null in the quantity $\mu$) the values of the $X_j$ and $k$ voltages are successively read out by means of comparison with the output of a four-dial decade potentiometer fed from a reference voltage. In practice, these readings are made only to three digits, the fourth digit being used if necessary to determine the direction for rounding of the third digit. The comparison is made by means of a differential amplifier followed by a phase-detector, as shown in Fig. 9. The phase-detector is used so that the sign of the difference is indicated by the galvanometer, thus facilitating finding the balance point. Since the final $x_j$'s are obtained as ratios of the $X_j$'s to $k$, it follows that no absolute measurement is required and that the accuracy of the read-out is determined by the accuracy of the ratios of the decade potentiometer. This potentiometer has an accuracy of 0.05 per cent of full scale.

Fig. 10 is a view of the operating console, showing the power switches and gain control at the left, the $\mu$ meter at top center, the thirteen controls for the $X_j$'s and $k$, and the read-out potentiometer and galvanometer on the right. The read-out selector is at the left of the galvanometer.

## VIII. Operation

When the numerical data of a problem has been scaled (if necessary) to fit the range of the machine, it is punched into a set of 13 cards. If there are less than 12 unknowns, zeros are inserted for all the missing elements. These cards are placed in the card-reading units, and the machine is then ready for solution. The usual process is to start with $k=1$, and all the $X_j$'s at zero. The common input voltage to all the $X_j$'s and $k$ is controllable by the large dial at the left of the console so that the large errors during the initial stages of solution do not overload the subsequent amplifiers and indicator.

The operator varies the $X_j$'s in such a manner as to decrease the error and as necessary he increases the input voltage to increase effectively the scale sensitivity of the error indicator. A systematic cycling process is used which results in the error decreasing toward zero and the $X_j$'s converging toward the solution. When the residual error is small enough to be consistent with the accuracy of the analogue, the results are read out in the manner previously described. The $x_j$'s are then obtained by calculating the ratios $X_j/k$.

A numerical check can be obtained by substituting these values into the problem and calculating the actual residual errors. If greater accuracy of results is desired

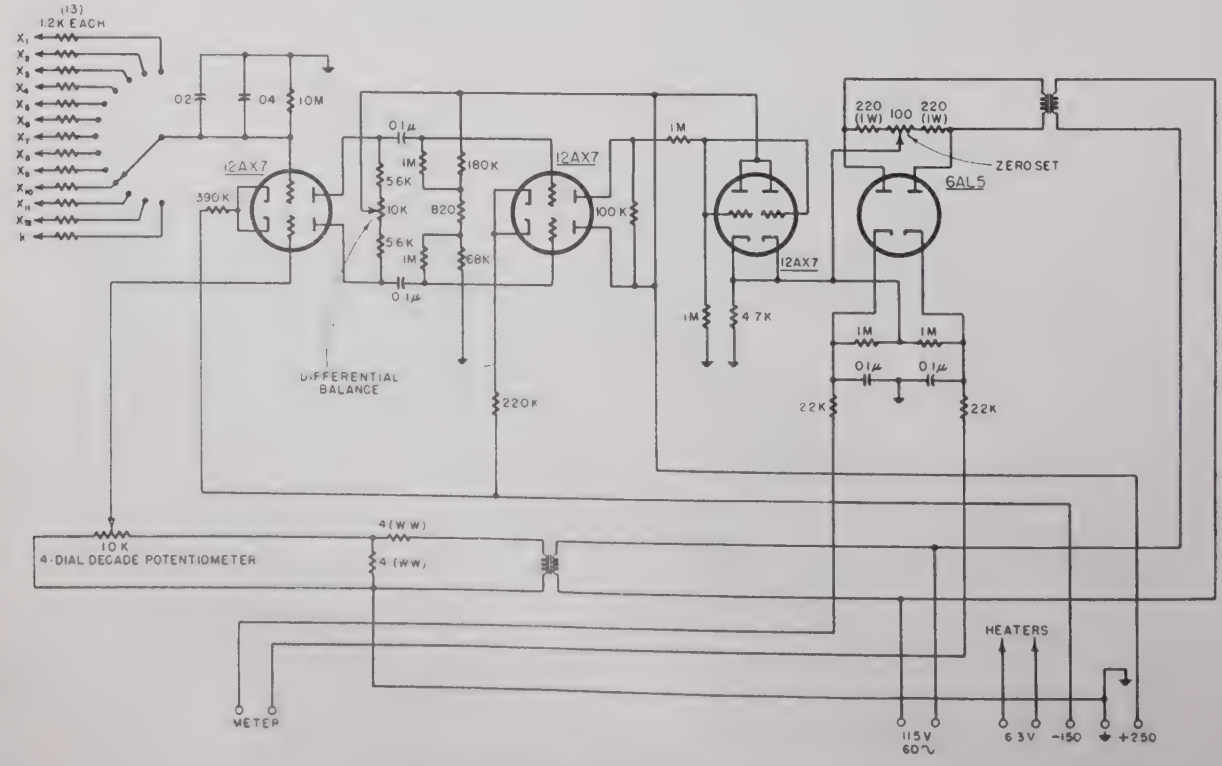


Fig. 9—Read-out potentiometer and galvanometer detector

Fig. 10—The operating console.

than is obtainable from the initial solution, these residual errors may be used to form a new set of equations in which the new unknowns are the errors in the $x_j$'s of the initial solution. The iteration procedure is simple and rapid, requiring the preparation of only one new punched card per step. As many iteration steps as required may be used to obtain the desired accuracy.

The usual type of problem with 12 equations requires about 15 minutes for solution and yields solutions of better than two-digit accuracy. Each iteration will then yield somewhat better than two additional digits.

## IX. Capabilities

For most problems of linear simultaneous equations, this device affords a considerable saving of labor over the usual methods of computing and has the advantage when iteration is used of correcting any errors made by the machine operator. Errors in one step are corrected in the next so that instead of being cumulative they are successively diminished. Of course, the machine is of a particular utility when the accuracy required can be obtained with a single solution.

There are certain other advantages of an analogue device for this purpose. For example, it allows investigation of the effect of varying one or more of the coefficients, without requiring a complete new solution.

The machine has been used for inversion of matrices up to the twelfth order. An $n^{th}$ order matrix requires $n$ separate solutions to obtain the inverse.

Sets of up to 6 equations with complex coefficients may be handled separating the real and imaginary parts, thus doubling the number of equations and the number of unknowns.

## X. Acknowledgment

The author wishes to acknowledge the invaluable assistance of Prof. F. J. Murray, of Columbia University, who is also responsible for the fundamental theory of this type of machine.

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# An Electronic DC to AC Converter for Use in Servo Systems*

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*Summary*—The usefulness of alternating current servomechanisms has been restricted in many cases by the difficulty of obtaining a satisfactory ac error signal.

The conversion from dc signals to an ac error signal, i.e., the modulation system, is shown to be a predominant source of difficulty.

A modulation circuit having characteristics, much improved over conventional types, has been developed. Practical application to a servomultiplier with results observed is discussed.

## I. Introduction

THIS PAPER describes a differential dc to ac converter or modulator for use in a servo system where the prime mover is an ac electric motor whose direction of motion is reversed by reversing the phase of the voltage applied to one of the windings, and whose torque is a function of the amplitude of the applied voltage. A linear relationship between voltage and torque for a given shaft rpm is usually desired. In addition, it is essential that the torque rpm characteristic be a decreasing monotone function over the full speed range.

Almost invariably, some type of modulator is involved in the operation of an ac servo. In some systems this may be a mechanical modulator, (e.g., selsyn, vibrator, "chopper"); in others an electronic modulator is used.

## II. Limitations of Electronic Modulators

Where dc signals are used, the modulator is usually the "weak link" in an ac servo system. Electronic modulators of usual design have very low efficiency because operation is dependent upon second-order variations in tube characteristics. The circuit configuration of a typical 400-cycle differential modulator is shown in Fig. 1.

This particular circuit produces about 28 millivolts peak-to-peak ac per volt dc differential input. This represents a voltage conversion efficiency of 2.8 per cent. This figure is typical of such modulators. Application of the signals to the control grids, to increase the conversion efficiency, restricts the usable input voltage range.

In addition, such a modulator is also unsatisfactory for many applications because the balance condition is not maintained for different dc levels with equal dc input signals. These effects may be overcome in some cases by very careful tube selection. In most cases, however, it is necessary to provide a dc differential error signal at a fixed level. The development of a dc error signal usually requires additional vacuum tubes, with attendant inaccuracies.

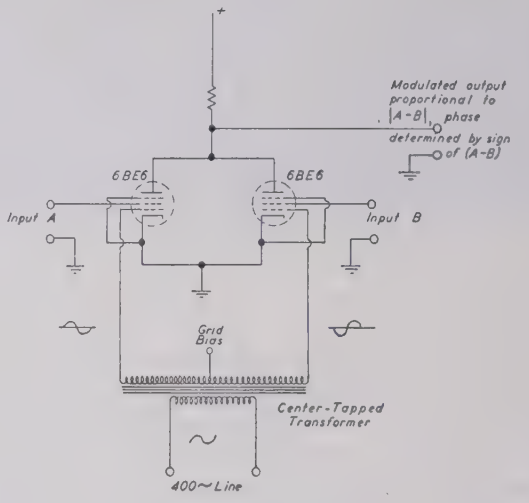


Fig. 1—$G_m$ variation modulator.

The presence of a second harmonic component of the order of 1 volt rms in comparison to a 10-millivolt carrier frequency signal for 1 volt differential input signal necessitates a high attenuation filter for removing this component, whose continuous presence would greatly overload amplifiers and motors.

Because of the low modulation efficiency, large gains are required in order to obtain sufficient voltage to operate a motor, and random and induced noises become a problem.

It is advisable for this reason to restrict the gain of the system for low frequency noise components. The use of a band-pass filter is indicated to remove simultaneously the second harmonic component. This filter should immediately follow the modulator, since noise may produce modulation in the amplifier due to nonlinearity.

## III. A Square-Wave Modulator for AC Servomechanisms

A modulator has been developed which has many advantages over the type illustrated by Fig. 1, and appears to be superior in several characteristics to any which has previously come to our attention.

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In particular, the modulator to be described is almost completely free from zero drifts, has high modulation efficiency, and is extremely linear in operation. The range of operation may be made very large.

The principle of operation of the modulator is indicated by analysis of Fig. 2. Square-wave voltages of opposite phase and approximately equal amplitude are applied between points 1 and 2 and ground. Input signals, assumed positive with respect to ground, from low impedance sources are applied at signal points $A$ and $B$. Slight circuit modifications permit the use of negative signals.

The maximum potential reached by point $C$ is the value of the signal at $A$; similarly, the maximum voltage at $D$ is the value of the signal at $B$. $V_1$ and $V_4$ prevent negative excursions of points $C$ and $D$. Thus at point $C$ is found a square wave whose amplitude is equal to the signal at $A$. At $D$ is produced a square wave whose amplitude is equal to the signal at $B$, and of opposite phase to the signal at point $C$. Let $E_x$ be the voltage to ground

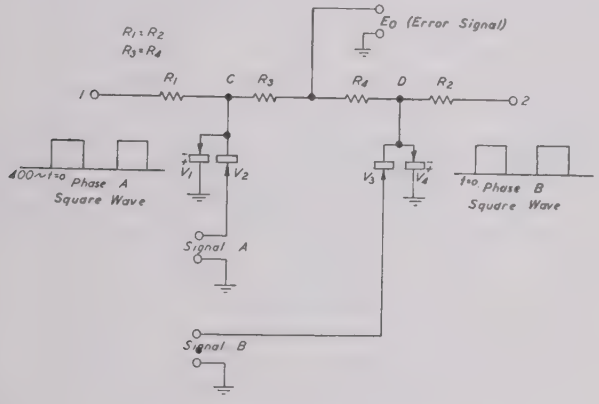


Fig. 2—Square-wave modulator.

at any point $x$. Since $R_3=R_4$, the output signal $E_0$ is equal to $\frac{1}{2}(E_C+E_D)$.

Circuit operation is clarified by considering four cases:

*Case I.* $E_A=E_B=0$ ($A$ and $B$ at ground potential)

The voltage at $C=0$. The voltage at $D=0$. $E_0=0$.

*Case II.* $E_A=E_B=E_{AB}$.

$E_C$ and $E_D$ are square waves of maximum amplitude $E_{AB}$, $E_0=E_{AB}/2$ but there is no ac component. (This is shown in Fig. 3(a)).

*Case III.* $E_a>E_b$.

The square waves at $C$ and $D$ are unequal, and the output at $E_0$ is $E_b/2$ plus a square wave whose amplitude is $(E_a-E_b)/2$ of the same phase as phase 1. (See Fig. 3(b)).

*Case IV.* $E_a<E_b$.

This is similar to Case III, except that the output square wave is now of opposite phase. (Fig. 3(c).)

It is seen that the ac component of the output in every case is a square wave whose phase is determined by the larger signal, and whose amplitude is half the difference between the signals.

The output wave may be represented by the Fourier series, $E=E_{dc}+E_1 \sin \omega t+E_3 \sin 3\omega t+\cdots$, where $E_{dc}$ is the dc component, $E_1$ is the amplitude of the fundamental component and $\omega=2\pi f$. The coefficient $E_1$ may be evaluated by standard methods[1] giving $E_1=(E_a-E_b)/\pi$. Thus the peak-to-peak amplitude of the fundamental component of the output voltage (equal to $2E_1$) is 63 per cent of the dc difference between the two input signals. Performance is an order of magnitude better than that of $g_m$ variation modulators of equal linear range.

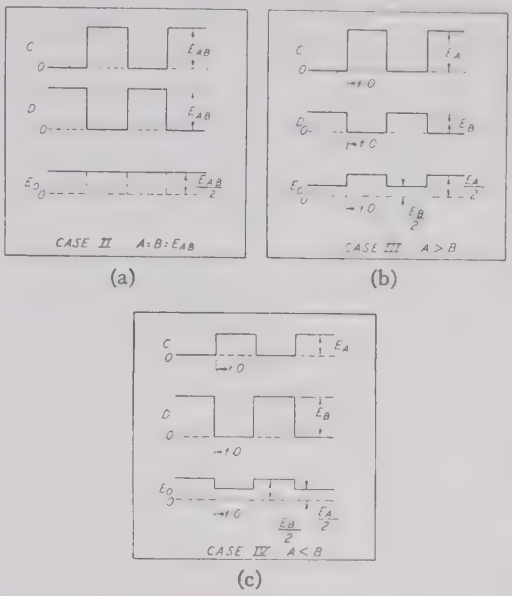


Fig. 3—Theoretical wave forms in a square-wave modulator.

If $V_1$, $V_2$, $V_3$, and $V_4$ (Fig. 2) be assumed perfectly conducting, and the impedance of signal sources $A$ and $B$ be assumed zero, the ac output of the device is entirely independent of the amplitude of $E_1$ and $E_2$, so long as neither signal voltage is larger than the amplitude of the respective square wave.

Since these conditions may not be met exactly, the balance condition is dependent upon the amplitude of $E_1$ and $E_2$. However, if $R_1$ and $R_2$ are kept large in comparison with the conduction resistance of $V_2$ and $V_3$ plus the respective source impedances of $A$ and $B$, the unbalance error will be very small.

When $A$ and $B$ are of low amplitude, unequal resistance in the diode conduction paths may cause significant errors, particularly where the source impedances are high. In such cases the use of cathode followers for driving the diodes may be desirable.[2] If both square waves

[1] L. Mautner, "Mathematics for Radio Engineers," p. 298, Pitman Publishing Co., New York, N. Y., 1947.

[2] B. Chance, "Some precision circuit techniques used in waveform generation and time measurement," *Rev. Sci. Inst.*, vol. 17, pp. 396–416; October, 1946.

are not identical in wave shape, summing them produces pulses (at the changeover points) having fundamental frequency components in quadrature with the fundamental components of $E_1$ and $E_2$. This usually does not decrease the accuracy of the system, since components in quadrature with the normal driving signal produce no torque in most servomotors. The heating produced by these components may, however, limit maximum usable sensitivity. Square waves having appreciable rise and fall times produce pulses which occur at twice line frequency. These cause little difficulty, since they may be reduced to a tolerable level with a simple filter.

## IV. Description of a Servomultiplier Using the Square-Wave Modulator

Figs. 4 and 5 show the application of the square-wave modulator to a servomultiplier used in a computer.

Fig. 4 is a simplified equivalent circuit of the multiplier. $\alpha$ is the percentage rotation of a balance potentiometer and $E_{dc}$ the voltage across this potentiometer. It is seen that $E_1(t)$ is balanced by $\alpha E_{dc}$ produced by the

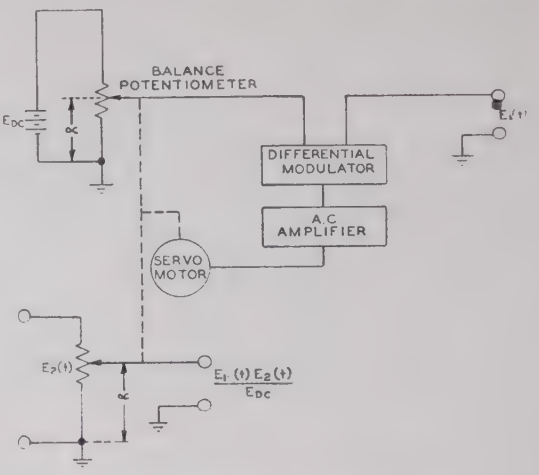


Fig. 4—Block diagram of servomultiplier.

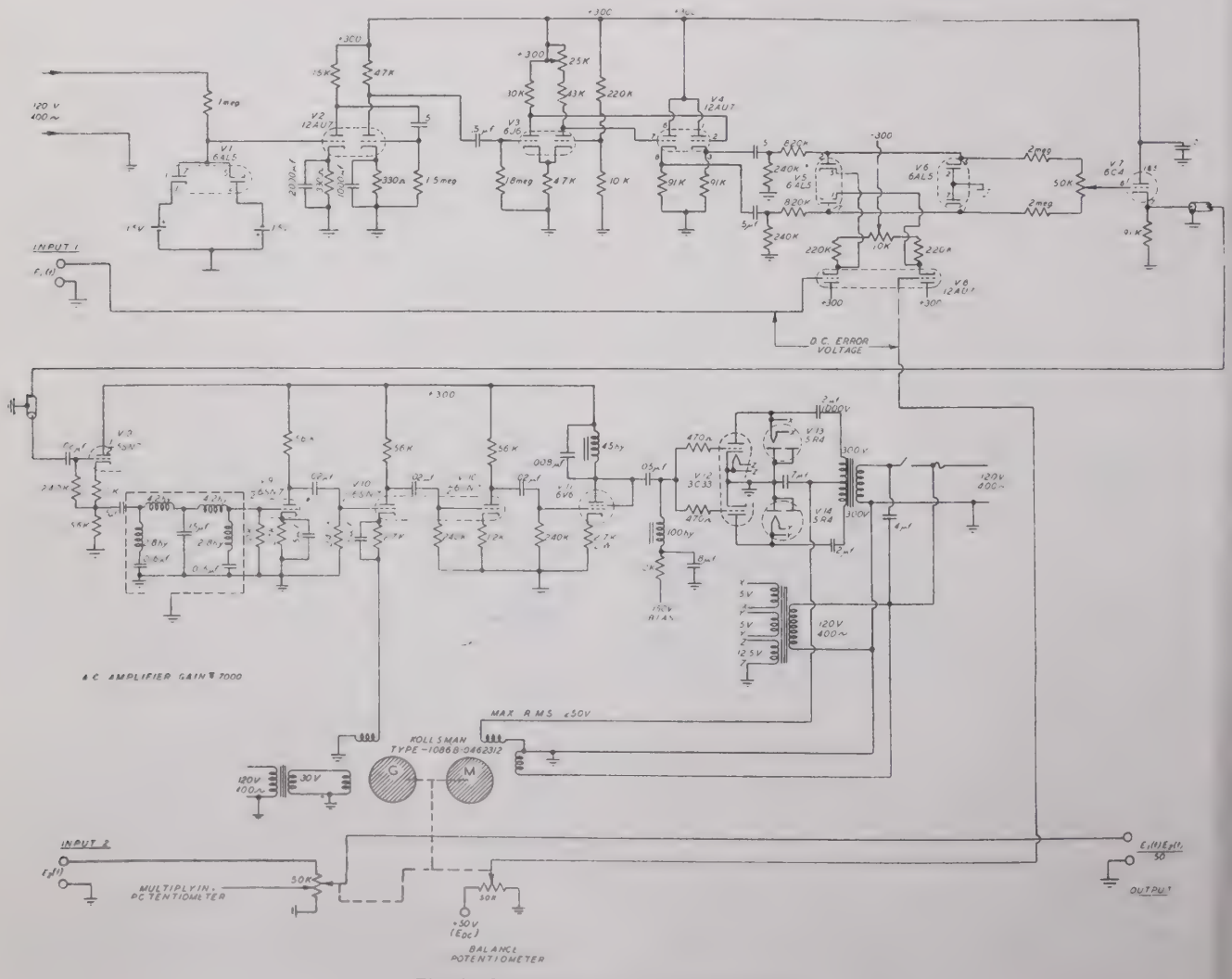


Fig. 5—Complete servomultiplier schematic.

rotation of the potentiometer. Balance is achieved by applying the amplified ac error signal from the differential modulator to the driving motor. In practice, the servo is able to position the potentiometer with sufficient accuracy to more than exhaust the accuracy of the potentiometer (0.1 per cent). Thus, very nearly, $\alpha = [E_1(t)/E_{DC}]$.

$E_2(t)$ is applied to a multiplying potentiometer, ganged with the balance potentiometer. Thus the output from arm to ground is $\alpha E_2(t)$ or $[E_1(t) \times E_2(t)/E_{DC}]$ The magnitude of $E_{dc}$ becomes a scale factor.

The complete circuit exclusive of power supplies is shown in Fig. 5. This particular servo is shown because it was initially provided with a conventional modultaor similar to Fig. 1, and therefore provides an excellent opportunity for comparison between the two modulators. After tests had been made on the original system using the conventional modulator, the system was changed to use the square wave modulator.

Tubes $V_1$ through $V_4$ provide square waves for the modulation circuit. Square waves of approximately 70 volts are applied to the modulation circuits from the cathode followers $V_4$. $V_5$ and $V_6$ comprise the square-wave modulator. Comparison with Fig. 2 will indicate the method of operation. $V_7$ provides a low impedance output for the square-wave error signal. $V_8$ provides low impedance driving signals for the modulating diodes.

Section 1 of $V_9$ provides the desired driving impedance for the low pass filter. ($V_7$ could have been eliminated, but since the modulator section was on another chassis, its use simplified cabling.) A filter as elaborate as that shown is probably not necessary, but was originally incorporated for use with the $g_m$ variation modulator. Section 2 of $V_9$, tubes $V_{10}$, and $V_{11}$ comprise an ac amplifier having a gain of approximately 7,000. $V_{12}$, $V_{13}$, and $V_{14}$ constitute a more or less conventional discriminator. The magnitude and phase of the voltages at the 3C33 tube grids determine the magnitude and phase of the current through the driven winding of the servomotor. The line phase of the servomotor is adjusted by means of a series capacitor so that the two windings are in phase quadrature. Damping is effected by introducing, in the cathode circuit of one section of $V_{10}$, the output of a derivative generator geared to the servomotor.

Performance data of the relative performance of the servomultiplier using both types of modulator are shown in Table I.

It is seen that considerable improvement has been made in the performance of the servo by substitution of the square-wave modulator for the original one.

With the original modulator the system was limited in maximum usable loop gain, because noise and quadrature components produced heating in the 3C33 stage. Quadrature components, due to stray pulse pickup in the output circuit of the modulator, also limited the maximum usable loop gain after substitution in the square-wave modulator. The circuit could be markedly improved in this regard by careful attention to shielding. Even without such refinement, however, the maximum usable loop gain was greater by more than an order of magnitude when the new modulator was used.

TABLE I

RELATIVE PERFORMANCE OF SERVOMULTIPLIER

| | Using $G_M$ variation Modulator | Using Square-Wave Modulator |
|---|---|---|
| Position accuracy | 1 part in 400 | 1 part in 10,000 |
| Frequency response | 6 db down at 5 cps | 6 db down at 24 cps |
| Zero drift | 1% | Not measurable better than 0.01% |
| Departure from linearity | 5% over 50 volt range | Not measurable better than 0.01% over 70 volt range |
| Transient response to step function | Rise time (.1 to .9) $100 \times 10^{-3}$ sec. | Rise time (.1 to .9) $18 \times 10^{-3}$ sec. (See Fig. 7) |
| Loop gain factor (restoring torque per radian displacement) | $1.8 \times 10^5$ dyne cm/radian (See Fig. 7) | $4.0 \times 10^6$ dyne cm/radian (See Fig. 7) |

Figs. 6(a) and 6(b) show the transient response of the system. It is seen that, whereas in Fig. 6(a), the rise time (10 to 90 per cent) is approximately 18 milliseconds, Fig. 6(b) shows a rise time of nearly 30 milliseconds. This anomaly is the result of difference in ampli-

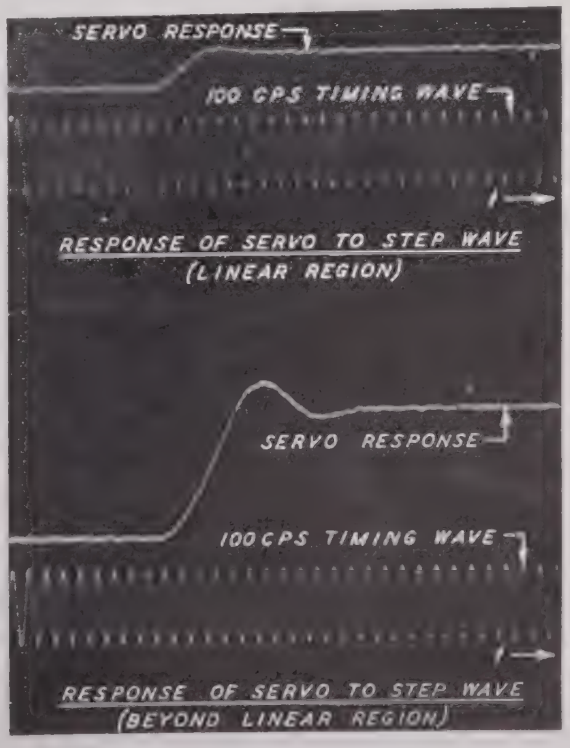


Fig. 6—Oscillograms of transient response of servo

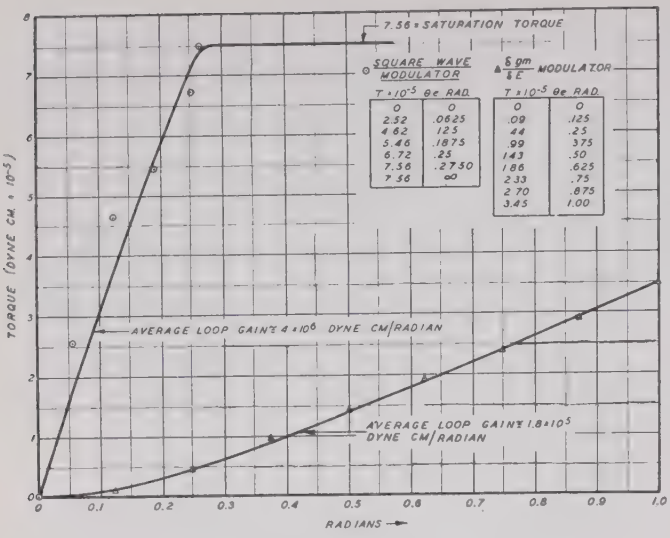


Fig. 7—Performance date of $g_m$ variation modulator and square-wave modulator.

tude, and is a well-known phenomenon in servo systems. Fig. 7 shows that if a step request for shaft position change greater than 0.25 radian is given, the servomechanism will rapidly accelerate to maximum speed and run at this speed until a new balance point is reached. Thus the initial rate of increase in Fig. 6(b) is greater than in Fig. 6(a) for the first 10 milliseconds, and then no further increase is observed. The overshooting seen in Fig. 6(b) is due to the nonlinear behavior of the system. More damping is used than that desirable if the servo were never rapidly displaced more than 0.25 radian.

It should be emphasized that no particular attempt was made to exhaust the possibilities in this design, because performance was more than satisfactory in the intended application.

## V. Conclusions

The performance indicates that the square-wave modulator system described is superior to types involving the use of curvature in tube characteristics.

Its sensitivity is not far from the maximum theoretically possible from non-amplifying devices.

The only modulators which appear to be capable of achieving better performance with regard to signal-to-noise ratio and limiting sensitivity are the mechanical types, such as the chopper and vibrator.

The use of the square-wave modulator should provide improved performance in many servo applications.

## VI. Acknowledgments

The aid and advice of Gorman R. Nelson on the servo problems, and the care used in construction and wiring of the device by J. B. Ruble are gratefully acknowledged.

# Resonant Circuits with Time-Varying Parameters*

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*Summary*—**With renewed interest in the superregenerator and similar circuits there has developed a need for a solution to the differential equation of a resonant circuit with time-varying parameters. An approximate solution is presented along with a criterion of error which determines the limits of accuracy of the solution. This error criterion shows that the solution may be applied to most communications problems with high accuracy. The method and ease of manipulation of the solution are demonstrated by application of the mathematics to the constant-parameter case. If direct manipulation of the formulas is not feasible, it may be easily applied to graphical analysis.**

## Introduction

WITH THE RENEWED interest in the superregenerator and the development of such systems as frequency modulation and servomechanisms, a great need has arisen for a useable solution to the differential equation of the resonant circuit with time-varying parameters. The basic problem is the mathematical formulation of an expression for the voltage across a resonant circuit as a function of the input current and the time-variation of the parameters $G$, $C$, and $L$. Previous papers[1–6] have treated the problem for the variation of one parameter only, but to the author's knowledge there has been no presentation of a solution

* Decimal classification: R141.2. Original manuscript received by the Institute, December 22, 1948; revised manuscript received, September 22, 1949.

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[5] Riebman, L., "Theory of the superregenerative amplifier," Proc. I.R.E., vol. 37, pp. 29–33; January, 1949.

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to the general case of a variation of all parameters simultaneously. Fox and Burns,[1] Bradley,[3,4] Riebman,[5] and Glucksman[6] all developed a quasistatic solution for the case of varying conductance only, but a determination of the accuracy of this solution has never been made. The purpose of this paper will then be twofold. First, the quasistatic solution shall be extended to the case of the variation of all parameters, and second, a criterion of error shall be developed for the solution presented. As to the advisability of depending upon a quasistatic solution, investigation seems to indicate that any attempt to arrive at an exact solution is extremely difficult and such a solution, if obtained, is of such a complexity as to have limited usefulness.

## The Differential Equation and Its Reduced Solution

The differential equation for a parallel resonant circuit[7] with time-varying parameters may be written as

$$\frac{d}{dt}(Ce) + Ge + \frac{1}{L}\int e\,dt = i \tag{1}$$

which upon manipulation becomes

$$e'' + e'\left(\frac{2C'}{C} + \frac{G}{C} + \frac{L'}{L}\right) + e\left(\frac{C''}{C} + \frac{L'C'}{LC} + \frac{L'G}{LC} + \frac{G'}{C} + \frac{1}{LC}\right) = \left(\frac{i'}{C} + \frac{L'}{LC}\,i\right), \tag{2}$$

where primes denote differentiation with respect to time. Now the solution to this equation for zero driving current and constant parameters is given very nearly by

$$e = E_0\epsilon^{(\alpha+j\omega_0)t} \tag{3}$$

where

$$\alpha = -\frac{G}{2C} \tag{3a}$$

and

$$\omega_0 = \frac{1}{\sqrt{LC}}\,.$$

What we must do, then, is attempt to modify this equation to satisfy the new conditions, i.e., the time-variation of the previous constants $G$, $C$, and $L$. Physical reasoning presents us with two pertinent facts. First, we know that the real component of the exponent will now involve the capacitance and the inductance since they are now instantaneous sources and sinks of energy, because of their variation with time. Second, by comparison with the mathematics of frequency modulation we realize that we must now take the integral of the exponent rather than its instantaneous value. Our first guess is that the solution to the reduced equation is best given by

$$e = E_0\epsilon^{\int(\alpha+j\omega_0)dt} \tag{4}$$

or, more generally,

$$e = \mathrm{Re}\left[2E_0\epsilon^{\int(\alpha+j\omega_0)dt}\right] \tag{4a}$$

where $\alpha$ is to be determined and

$$\omega_0 = \frac{1}{\sqrt{LC}}\,.$$

Writing (2) in its reduced form as

$$e'' + Ae' + Be = 0, \tag{5}$$

we will now try to find an equation of the form

$$e'' + Ae' + B^*e = 0, \tag{6}$$

which satisfies the approximate formula. By placing this restriction on the approximate solution we shall determine $\alpha$. Differentiating (4) and substituting into (6) we obtain

$$\alpha' + j\omega_0' + \alpha^2 - \omega_0^2 + 2j\alpha\omega_0 + A\alpha + jA\omega_0 + B^* = 0. \tag{7}$$

Now we know that $A$ is given by

$$A = \frac{2C'}{C} + \frac{G}{C} + \frac{L'}{L}\,.$$

Thus, equating reals and imaginaries, we obtain

$$\alpha = -\frac{A}{2} - \frac{1}{2}\frac{\omega_0'}{\omega_0} = -\frac{G}{2C} - \frac{3}{4}\frac{C'}{C} - \frac{1}{4}\frac{L'}{L} \tag{8}$$

and

$$B^* = \frac{1}{LC} + \frac{7}{8}\frac{L'C'}{LC} + \frac{3}{4}\frac{C''}{C} + \frac{G'}{2C} + \frac{3}{16}\left(\frac{C'}{C}\right)^2 - \frac{1}{16}\left(\frac{L'}{L}\right)^2 + \frac{L''}{4L} + \frac{GC'}{2C^2} + \frac{1}{4}\left(\frac{G}{C}\right)^2 + \frac{1}{2}\frac{L'G}{LC}\,. \tag{9}$$

We now have an exact solution to the equation

$$e'' + Ae' + B^*e = 0, \tag{10}$$

which differs from the exact equation for the resonant circuit with time-varying parameters only in the linear coefficient $B^*$. We note that this error in the coefficient is

[7] Henceforth we shall treat the parallel circuit only. The solution to the series circuit is the same with the usual change of $G$ to $R$, $L$ to $C$, etc.

$$B^* - B = \frac{3}{16}\left(\frac{C'}{C}\right)^2 + \frac{L''}{4L} + \frac{GC'}{2C^2} + \frac{1}{4}\left(\frac{G}{C}\right)^2 - \frac{1}{16}\left(\frac{L'}{L}\right)^2 - \frac{1}{8}\frac{L'C'}{LC} - \frac{1}{4}\frac{C''}{C} - \frac{1}{2}\frac{L'G}{LC} - \frac{G'}{2C}. \quad (11)$$

We must now develop an error criterion to establish the relation of the magnitude of this error to the accuracy of the approximate solution.

## The First-Order Error

Defining $e$ as the approximate solution and $\delta$ as the first-order error in this solution, we write the following equations:

$$e'' + Ae' + B^*e = 0 \quad (12)$$

$$(e + \delta)'' + A(e + \delta)' + B(e + \delta) = 0. \quad (12a)$$

Now the above equations are linear; we may therefore subtract them, obtaining,

$$\delta'' + A\delta' + B\delta = (B^* - B)e. \quad (13)$$

Solving this equation by our approximate solution and the method of variation of parameters[8] the first-order error is found to be

$$\delta = Re\left[2E_1\epsilon^{\int(\alpha+j\omega_0)dt} + \epsilon^{\int(\alpha+j\omega_0)dt}\int\frac{(B^* - B)E_0\ t}{j\omega_0}\right]. \quad (14)$$

Here $E_1$ determines the initial value of the error, however this will of necessity be zero since we have knowledge of the initial voltage across the circuit, and thus make the error zero. Therefore the corrected solution to the reduced differential equation becomes

$$e + \delta = \mathrm{Re}\left[2E_0\epsilon^{\int(\alpha+j\omega_0)dt} \times\left(1 + \int\frac{B^* - B}{2j\omega_0}dt\right)\right], \quad (15)$$

where $(B^* - B)$ is defined by (11).

Let us now examine the error term. Assuming the time-variation to be periodic, we may specify that $(B^* - B)$ is of the form

$$(B^* - B) = K_0 + K_1\cos(pt + \phi_1) + K_2\cos(2pt + \phi_2) + \cdots + K_n\cos(npt + \phi_n), \quad (16)$$

where $p$ is the fundamental frequency[9] of the time-variation of parameters. Now the constant $K_0$ may be dropped since we see that it actually produces a slight correction in the average frequency of the resonant circuits. This would be expected, since we have used the approximate formula for $\omega_0$. Examination of the integral verifies this interpretation since $K_0$ produces a linearly-increasing phase shift with time whenever the integral is much smaller than one. Now the maximum instantaneous value of the remaining terms will be

$$|B^* - B - K_0|_{\max} \leqq K_1 + K_2 + \cdots K_n, \quad (17)$$

and the maximum possible value for the integral will be

$$\left|\int\frac{B^* - B - K_0}{2j\omega_0}dt\right|_{\max} \leqq \frac{1}{\omega_0}\left(\frac{K_1}{p} + \frac{K_2}{2p} + \cdots + \frac{K_n}{np}\right) \leqq \frac{1}{\omega_0 p}|B^* - B - K_0|_{\max}. \quad (18)$$

Thus the criterion for the accuracy of the approximate solution will be

$$\left|\int\frac{B^* - B - K_0}{2j\omega_0}dt\right|_{\max} \ll 1 \quad (19)$$

or

$$|B^* - B - K_0|_{\max} \ll \omega_{0\min}p. \quad (20)$$

What we require for accuracy, then, is that the maximum deviation in the magnitude of $(B^* - B)$ be much less than the product of $p$ and the minimum value of $\omega_0$. If a transient solution is desired, (19) may be applied directly. Application of this criterion to most problems encountered has shown that the formula in general produces accurate results.

## The General Solution

Having obtained a reduced solution with error criterion, we may now derive the complete solution. By the method of variation of parameters[8] this is found to be

$$e = \mathrm{Re}\left[2E_0\epsilon^{\int(\alpha+j\omega_0)dt} + \epsilon^{\int(\alpha+j\omega_0)dt}\int\frac{\left(i' + \frac{L'}{L}i\right)\epsilon^{\int(\alpha+j\omega_0)dt}dt}{j\omega_0 C}\right]. \quad (21)$$

Placing limits on the proper integrals such that we may apply the equation to a circuit at time, $t = a$,

[8] L. R. Ford, "Differential Equations," McGraw-Hill Book Co., New York, N. Y., 1946, pp. 75–77.

[9] For simplicity we shall call $\omega$ frequency rather than angular velocity.

$$e = \mathrm{Re}\left[ 2E_0\epsilon^{\int_0^t(\alpha+j\omega_0)\,d\tau} + \epsilon^{\int(\alpha+j\omega_0)\,dt}\int_0^t \frac{\left(i' + \frac{L'}{L}\,i\right)\epsilon^{-\int(\alpha+j\omega_0)\,d\tau}\,d\tau}{j\omega_0 C}\right] \quad (22)$$

We must now place definite limits on the remaining integrals. Writing these as follows:

$$\int(\alpha + j\omega_0)dt = \int_0^t (\alpha + j\omega_0)dx + C_1 \quad (23)$$

$$\int(\alpha + j\omega_0)d\tau = \int_0^\tau (\alpha + j\omega_0)dx + C_2, \quad (24)$$

we see that $C_1 = C_2$ since the integrals were derived in similar fashion. Bringing the second exponential within the integral

$$e = \mathrm{Re}\left[ 2E_0\epsilon^{\int_0^t(\alpha+j\omega_0)\,d\tau} + \int_0^t \frac{\left(i' + \frac{L'}{L}\,i\right)\epsilon^{\int_\tau^t(\alpha+j\omega_0)\,dx\,d\tau}\,d\tau}{j\omega_0 C}\right]. \quad (25)$$

Note that under the main integral $(\alpha+j\omega_0)$ in the exponent is a function of $x$, and the remaining terms, with the exception of $t$, are all functions of $\tau$. This is the key equation for the solution of any problem to be treated.

To demonstrate the use of the above equation in the treatment of a steady-state problem, let us take the simple case of the constant-parameter circuit merely to show how the equation may be manipulated. We wish to find the response of the circuit to a current given by

$$i = I_0 \cos \omega_s t = I_0\,\frac{(\epsilon^{j\omega_s t} + \epsilon^{-j\omega_s t})}{2} \quad (26)$$

Then

$$i' = j\omega_s I_0\,\frac{(\epsilon^{j\omega_s t} - \epsilon^{-j\omega_s t})}{2} \quad (27)$$

where $\omega_s$ is the frequency of the applied current. Substituting into (25), having dropped the first term, since we desire the steady-state solution,

$$e = \mathrm{Re}\left[ \int_{-\infty}^t \frac{\left(j\omega_s + \frac{L'}{L}\right) I_0\epsilon^{\int_\tau^t(\alpha+j\omega_0)\,dx}\epsilon^{j\omega_s\tau}\,d\tau}{2j\omega_0 C} - \int_{-\infty}^t \frac{\left(j\omega_s - \frac{L'}{L}\right) I_0\epsilon^{\int_\tau^t(\alpha+j\omega_0)\,dx}\epsilon^{-j\omega_s\tau}\,d\tau}{2j\omega_0 C}\right]. \quad (28)$$

We also set the lower limit of the integral equal to $-\infty$ for steady-state applications. At this point we specify that $G$, $C$, and $L$ are constant. Then

$$e = \mathrm{Re}\left[ \int_{-\infty}^t \frac{j\omega_s I_0\epsilon^{(t-\tau)(\alpha+j\omega_0)}\epsilon^{j\omega_s\tau}\,d\tau}{2j\omega_0 C} - \int_{-\infty}^t \frac{j\omega_s I_0\epsilon^{(t-\tau)(\alpha+j\omega_0)}\epsilon^{-j\omega_s\tau}\,d\tau}{2j\omega_0 C}\right]. \quad (29)$$

The second integral is now dropped because of the $\epsilon^{-j(\omega_s+\omega_0)\tau}$ term. This is the same as the narrow-band approximation used in the more familiar treatment. The resultant steady-state expression for the voltage across the resonant circuit is

$$e = \mathrm{Re}\left[\frac{\omega_s I_0\epsilon^{-(G/2C)t}\epsilon^{j\omega_0 t}}{2\omega_0 C}\int_{-\infty}^t \epsilon^{(G/2C)\tau}\epsilon^{j(\omega_s-\omega_0)\tau}\,d\tau\right] \quad (30)$$

which, when the integral is evaluated, is

$$e = \mathrm{Re}\left[\frac{\omega_s I_0\epsilon^{j\omega_s t}}{2\omega_0 C\left(\frac{G}{2C} + j\omega_s - j\omega_0\right)}\right]. \quad (31)$$

This is more readily recognized if we cancel $\omega_s$ and $\omega_0$, since they are approximately equal in the region of importance. The final result is

$$e = \mathrm{Re}\left[\frac{I_0}{G + 2j(\omega_s - \omega_0)C}\,\epsilon^{j\omega_s t}\right] \quad (32)$$

which takes on the familiar form of the single-tuned response curve.

The application of the equations to actual time-varying parameter problems will not be presented here, as we feel that such a presentation cannot have sufficient generality in any specific case to warrant its inclusion in a paper of this type. The reader is referred to such papers as those of Bradley,[3,4] and Riebman,[5] for an application for one specific parameter only. It might be noted that the mathematical formulation is easily adaptable to graphical solution where direct integration is not feasible.

## Acknowledgment

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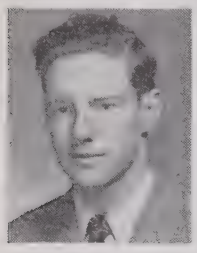
# Contributors to Waves and Electrons Section

Robert H. Kingston (S'48) was born on February 13, 1928, in Somerville, Mass. He received the degrees of B.S. and M.S. in electrical engineering in 1948 from the Massachusetts Institute of Technology. Enrolled in the Cooperative Course in Electrical Engineering at MIT, he also received sixteen months of industrial practice at the Philco Corporation during the period from November, 1945, to June, 1948. Since September, 1948, he has been engaged in graduate study in the physics department at MIT. At present, Mr. Kingston is a research assistant in the Research Laboratory of Electronics at that institution. He is a member of Sigma Xi and Tau Beta Pi.



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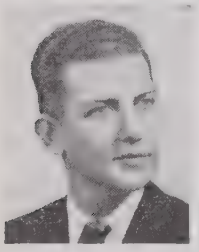
Herbert B. Michaelson (M'49) was born in Washington, D. C., on December 29, 1916. He attended Temple University in 1943, and at that time began free-lance writing on electronics subjects. He then served in the Army Signal Corps for three years, receiving a commission in 1944 as a microwave radio-link officer. From 1946 to the present time he has been employed by Sylvania Electric Products Inc. as a technical writer. Mr. Michaelson prepares literature surveys on topics related to electron tube development projects. He is now engaged in work toward the B.S. degree at the Polytechnic Institute of Brooklyn.



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Paul Mandel (A'45) was born on February 15, 1906, in Szolnok, Hungary. In 1929, he received the diploma of electrical engineering from the Polytechnical High School of Berlin, Germany, and joined the staff of the Dr. G. Seibt Laboratories in the same year. Here he was engaged in research work on acoustical systems and broadcasting receivers until 1931, when he became associated with the Sachsenwerk A. G. in Dresden as head of the Broadcasting Receiver development, remaining until 1933. He was engaged from 1936 in television research work in the laboratories of the Compagnie des Compteurs, Montrouge, France, as head of the research group on high definition television systems, large-screen television projectors, and television receivers. In 1949, he joined the Television Laboratories of the Radio-Industrie in Paris, to confine his efforts to the further development of high definition television systems as chief of a development section.

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Raymond C. Miles (S'41–A'44–M'49) was born at Indianapolis, Ind., on May 6, 1920. After receiving the B.S.E.E. degree from Purdue University in 1942, he joined the staff of the Federal Telegraph Company, which later became Federal Telephone and Radio Corporation. His duties included prolonged stays at Gilfillan Bros., Inc.; Hazeltine Electronics Corp.; International Telephone and Radio Laboratories; and Haller, Raymond and Brown, in connection with engineering liaison and co-operative development programs.

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In 1947, Mr. Miles became chief engineer of Haller, Raymond and Brown, Inc., State College, Pa., where he is engaged in the supervision of applied research and development work on radar, electronic navigation devices, military applications of facsimile recording, and related electronic subjects.

❖

E. E. St. John (A'47) was born on November 27, 1918, in Knox County, Mo. He has held an amateur radio operator's license since 1933. After graduation from high school, he attended the University of Colorado for a short time, and then engaged in work in the electronics field for several years. Early in 1942 he became an instructor at the Lexington, Ky., Radar School, where he remained until late 1943 when he accepted a position with Tennessee Eastman Corporation at Oak Ridge, Tenn., as a training school instructor. Later he did supervisory work at the Uranium 235 Electromagnetic Separation Plant.

E. E. ST. JOHN

In November, 1945, Mr. St. John left the Manhattan Project to join the Allen B. Dumont Laboratories in Passaic, N. J., as a research engineer, where his efforts were mainly expended on the circuit design for the Dumont Image Orthicon Camera. In the fall of 1946, he returned to Oak Ridge to work at the NEPA (Nuclear Energy for Propulsion of Aircraft) Project. Employed as an electronics engineer by the Air Force contractor, Fairchild Engine and Airplane Corp., he has been engaged in original circuit design on video circuits, computers, servos, and nuclear instrumentation.

❖

Robert M. Walker (A'37–M'40–SM'43) was born on June 2, 1907, in Pullman, Wash. In 1922 he became an active radio amateur and in 1923 served as operator for two of the pioneer broadcasting stations in Seattle. He entered the broadcast engineering field in 1932, and in 1935 operated the Seattle, Washington, and Portland, Oregon, sky-wave field-intensity recording stations of the Clear Channel Secondary Coverage Survey.

R. M. WALKER

From 1935 through 1941, Mr. Walker was assistant engineer for the broadcast stations KOMO and KJR in Seattle as transmitter supervisor, and also served as consulting engineer for other broadcast stations in the Pacific northwest. In 1940 he was Chairman of the Seattle Section of the IRE.

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❖

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W. L. WEBB

Mr. Webb became director of engineering and research at the radio division of the Bendix Aviation Corp in Baltimore., Md., in 1936. In this position he is responsible for the engineering, research, test, inspection, and patent departments.

A member of Sigma Tau, Tau Beta Pi, and the AIEE, Mr. Webb won the U. S. Navy Certificate of Commendation for his work during World War II.

# Abstracts and References

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NOTE: The Institute of Radio Engineers does not have available copies of the publications mentioned in these pages, nor does it have reprints of the articles abstracted. Correspondence regarding these articles and requests for their procurement should be addressed to the individual publications and not to the IRE.

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## ACOUSTICS AND AUDIO FREQUENCIES

016:534 2995
**References to Contemporary Papers on Acoustics**—A. Taber Jones. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 440–449; July, 1949.) Continuation of 2683 of November.

534.21 2996
**On Ray Geometry for Parallel-Layered Media**—W. Gauster-Filek von Wittinghausen. (*Akus. Zeit.*, vol. 8, pp. 175–185; October, 1943.) The geometrical properties of sound-ray curves for a stratified medium with arbitrary velocity distribution are investigated.

534.23 2997
**Sound Transmission through Multiple Structures Containing Flexible Blankets**—L. L. Beranek. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 419–428; July, 1949.)

534.23:620.179.16 2998
**On Sound Transmission through Metal Plates in Liquids for Oblique Incidence of Plane Waves**—J. Götz. (*Akus. Zeit.*, vol. 8, pp. 145–168; October, 1943.) Theory and experimental results with particular reference to the use of ultrasonic waves at oblique incidence for flaw detection in metal plates.

534.231 2999
**On the Sound Field of a Piston Membrane**—A. Schoch. (*Akus. Zeit.*, vol. 6, pp. 318–326; November, 1941.) Analysis shows that the sound field of a piston membrane in a rigid wall is made up of two parts: a plane wave, as for the limiting case in geometrical optics, and a diffraction wave from the edge of the membrane. The effect of the diffraction wave vanishes, in general, for infinitely small wavelengths, leaving only the plane wave. For circular membranes, however, singular lines are found along which the effect of the edge wave does not vanish for very small wavelengths.

534.26 3000
**The Diffraction of Sound by Rigid Disks and Rigid Square Plates**—F. M. Wiener. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 334–347; July, 1949.) Discussion of experimental technique and comparison of results with theory for various wavelengths and angles of incidence.

534.26 3001
**Diffraction of Sound by a Circular Disk**—A. Leitner. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 331–334; July, 1949.) The near and distant diffraction fields of a circular disk of zero thickness are plotted according to an exact theory. The results are compared with the Kirchhoff approximation and recent experimental data.

534.321.9:534.22 3002
**The Velocity of Ultrasonic Waves in an Electric Field and the Effect of Temperature**—A. Bonetti. (*Ricerca Sci.*, vol. 18, pp. 777–780; July, 1948.) Variation of the velocity of 4.2-Mc waves in nitrobenzene with temperature was found in agreement with the theory of polar liquids. No variation due to the application of a field of 7,000 V/cm in the direction of propagation of the ultrasonic beam could be detected.

534.321.9:534.232 3003
**Focusing Ultrasonic Radiators**—G. W. Willard. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 360–375; July, 1949.) A spherical-shell radiator giving greatly improved energy concentration can be obtained by varying the thickness of the radiator to compensate for radial variations of the frequency constant.

534.321.9:534.24 3004
**Theory of Ultrasonic Intensity Gain due to Concave Reflectors**—V. Griffing and F. E. Fox. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 348–351; July, 1949.)

534.321.9:534.24 3005
**Experimental Investigation of Ultrasonic Intensity Gain in Water Due to Concave Reflectors**—F. E. Fox and V. Griffing. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 352–359; July, 1949.)

534.321.9:679.5 3006
**Ultrasonic Lenses of Plastic Materials**—D. Sette. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 375–381; July, 1949.)

534.323 3007
**On the Subjective Effect of Sound-Spectrum Variations**—E. Löb. (*Akus. Zeit.*, vol. 6, pp. 279–294; September, 1941.) An experimental investigation.

534.612.4 3008
**The Accuracy of Measurements by Rayleigh Disc**—W. West. (*Proc. Phys. Soc.* (London), vol. 62, pp. 437–444; July 1, 1949.) A review of proposals for altering König's formula indicates that there is insufficient evidence for changing the numerical constant in the formula. Comparisons between Rayleigh-disk and other methods of microphone calibration are discussed, and the possibility of difference due to reaction of the vibration of the diaphragm on the sound pressure is considered.

534.614:533.5 3009
**On the Velocity of Sound in Air at Low Pressures**—J. Maulard. (*Compt. Rend. Acad. Sci.* (Paris), vol. 229, pp. 25–26; July 4, 1949.) The results of experiments on transmission through a steel tube (internal diameter 8 cm, length 27.43 m) buried underground, confirm that the velocity shows little change from atmospheric pressure down to 15 cm Hg. Between 15 and 4 cm Hg, however, the velocity increases according to a law sensibly exponential. At 10 cm Hg the increase is about 1.5 per cent and at 4 cm Hg about 4 per cent.

534.75:533.723 3010
**Brownian Movement and Hearing**—H. de Vries. (*Physica's Grav.*, vol. 14, pp. 48–60; January, 1948. In English.) Results were obtained for the Brownian movement of the ear as a whole, which were compatible with the auditory threshold actually observed. Present theories of the mechanism of hearing do not reconcile the strong thermal agitation of the sense cells with the low audible threshold.

534.78 3011
**Auditory Masking of Multiple Tones by Random Noise**—T. H. Schaffer and R. S. Gales. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 392–398; July, 1949.)

534.782 3012
**Investigations with Artificial Vocal Resonators**—T. v. Tarnóczy. (*Akus. Zeit.*, vol. 8, pp. 169–175; October, 1943.)

534.79 3013
**The Loudness and Loudness Matching of Short Tones**—W. R. Garner. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 398–403; July, 1949.)

534.834 3014
**The Lined Tube as an Element of Acoustic Circuits**—C. T. Molloy. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 413–418; July, 1949.) A method is given for calculating the performance of acoustic circuits containing long or short lined ducts of diameters less than $\lambda/2$ for sound in free air. Equivalent electrical circuits are discussed. Formulas applicable to filters using lined ducts are listed.

534.84 3015
**Architectural Acoustics of German Theatres and Concert Halls, Prague**—W. Frank. (*Akus. Zeit.*, vol. 8, pp. 205–208; December, 1943.)

Measurements of (a) loudness, (b) reverberation times under different conditions and for different frequencies, and (c) relative absorption for different frequencies, are shown graphically.

534.84 3016
**Variable Room-Acoustics**—K. F. Darmer. (*Akus. Zeit.*, vol. 6, pp. 331–350; November, 1941.) Methods are described for varying the acoustic properties of rooms (theaters, concert halls, etc.) to secure the best results for speech, music, etc.

534.845 3017
**Sound Absorption by Porous Materials: Part 2**—C. W. Kosten. (*Appl. Sci. Res.*, vol. B1, pp. 241–250; 1949.) The case of narrow tubes is considered, in which the flow is essentially of the Poiseuille type. A correction to the velocity of sound analogous to that of Kirchhoff for wide tubes is obtained. The correction is not important for the damping or the sound velocity, but it may greatly affect the absorption coefficients of porous materials. See also 2144 of 1948 (v.d. Eijk, Kosten, and Kok).

534.845:666.3 3018
**On the Air-Flow Resistance of Porous Ceramic Materials**—H. F. Gerdien. (*Akus. Zeit.*, vol. 6, pp. 329–331; November, 1941.) The sound absorbing power of a porous material can be found from knowledge of its thickness, porosity, and air-flow resistance. Measurements of the resistance for 13 ceramic filters and 8 of Jena glass show that the resistance is related to the diameter and length of the pores in a material by a law of the Hagen-Poiseuille type.

534.861:785.1 3019
**The Broadcasting of Orchestras**—F. W. Alexander. (*BBC Quart.*, vol. 4, pp. 118–128; July, 1949.) Discussion of microphone placing, acoustic properties of concert halls, tone balance, loudness, use of echo room, etc.

621.3.012.8:621.395.623.45 3020
**Equivalent Electrical Circuit for the Piezoelectric Sound-Receiver**—O. Schäfer. (*Akus. Zeit.*, vol. 6, pp. 326–328; November, 1941.)

621.392.51 3021
**Piezoelectric Transducers**—W. Roth. (PROC. I.R.E., vol. 37, pp. 750–758; July, 1949.) A piezoelectric transducer operating in the thickness mode is represented as a six-terminal network. The mesh equations, electromechanical impedance matrix, and equivalent circuit valid for any general conditions of loading and frequency are obtained. Equations for the electrical driving-point impedance are derived.

621.395.61/.62 3022
**A Low-"$Q$" Directional Magnetostrictive Electroacoustic Transducer**—L. Camp and F. D. Wertz. (*Jour. Acous. Soc. Amer.*, vol. 21, pp. 382–384; July, 1949.) Description of a lamination design for the magnetostrictive motors of a directional transducer array. Efficient operation is possible with a $Q$ of 6 under a full water load.

621.395.61 3023
**A New Dynamic Microphone**—W. Baer. (*Akus. Zeit.*, vol. 8, pp. 127–135; August, 1943.) Theory is based on the equivalent circuit. Details of the construction of the Beyer moving-coil microphone are given.

621.395.61 3024
**The B.B.C.-Marconi Ribbon Microphone Type AXBT**—E. T. Wrathall. (*Marconi Rev.*, vol. 12, pp. 92–103; July and September, 1949.) Designed in 1933 by the research department of the BBC for studio use. The microphone consists of a crimped Al-foil ribbon supported between specially shaped pole-pieces of a powerful Alcomax permanent magnet. The ribbon resonates at a subaudio frequency; the amplitude of its motion is proportional to the particle velocity of the incident sound wave. The horizontal and vertical polar curves of sensitivity have the figure-of-eight shape. The ribbon is electrically screened and is protected from draughts and dust. Maintenance requirements are negligible over long periods.

621.395.61:621.396.822 3025
**The Noise Level of High-Grade Microphones**—W. Weber. (*Akus. Zeit.*, vol. 8, pp. 121–127; August, 1943.) The noise levels of microphones of the dynamic and capacitive types, made by several well-known firms, were calculated and determined experimentally. For the dynamic microphones the thermal noise of the internal resistance is about 10 times that of the first tube of the amplifier. The capacitor microphone itself produces no noise, but noise voltages are introduced by the load resistance in the low-frequency arrangement and by the resonance resistance of the oscillatory circuit in the high-frequency arrangement. The noise level in the low-frequency arrangement is again higher than that of the first amplifier tube, at the lower and middle frequencies by about 10 db, falling at the higher frequencies to about that of the tube. With suitable design of the high-frequency arrangement the noise level can be reduced by about 10 db.

621.395.623.7:791.45 3026
**Theater Loudspeaker Design, Performance and Measurement**—J. K. Hilliard. (*Jour. Soc. Mot. Pic. Eng.*, vol. 52, pp. 629–640; June, 1949.)

621.395.623.7.089.6 3027
**Physical Measurements of Loudspeaker Performance**—Veneklasen. (*See* 3207.)

621.395.625.2:621.392.52 3028
**Crossover Filter for Disk Recording Heads**—Roys. (*See* 3085.) (*Broadcast News*, no. 55, pp. 20–23; June, 1949.)

621.395.625.3 3029
**Tape Characteristics for Audio Quality**—R. Marchant. (*Tele-Tech*, vol. 8, pp. 30–33, 57; July, 1949.) A general survey covering the electrical and mechanical properties of the tape, mechanical requirements of the driving and tension devices and the playback head, the effect of the main supply voltage on the tape velocity, and precautions to avoid deterioration of the tape in storage.

621.395.625.3 3030
**Factors Affecting Spurious Printing in Magnetic Tapes**—S. W. Johnson. (*Jour. Soc. Mot. Pic. Eng.*, vol. 52, pp. 619–627; June, 1949. Discussion, pp. 627–628.) Study of the amount of signal printed through from adjacent layers in a roll of magnetic type. The effects of time, temperature, and output level of the original recording are considered.

621.395.625.3 3031
**Optimum High-Frequency Bias in Magnetic Recording**—G. L. Dimmick and S. W. Johnson. (*Broadcast News*, no. 55, pp. 4–7; June, 1949.)

534.321.9:620.179.16 3032
**Ultrasonics [Book Review]**—B. Carlin. Publishers: McGraw-Hill Book Co., New York, 1949, 270 pp., $5.00. (*Electronics*, vol. 22, pp. 209–210; August, 1949.) For readers with an engineering viewpoint. Piezoelectric and magnetostriction generators are considered as well as cw and pulsed systems. The use of ultrasonics for flaw detection is the application most thoroughly covered.

## ANTENNAS AND TRANSMISSION LINES

621.315.1:531.221.8 3033
**Graphical Calculation of Tension Tables for Overhead Lines and Horizontal Copper-Wire Aerials**—C. M. A. Carranza. (*Rev. Telecommun.* (Madrid), vol. 3, pp. 16–23; June, 1948.) Abacs for determining tension, sag, and safety factor as a function of temperature for various lengths of span and diameters of wire.

621.315.212:621.3.09 3034
**Coaxial Cables**—P. Schiaffino and L. Albanese. (*Poste e Telecomun.*, vol. 17, pp. 85–104; February, 1949.) A study of propagation phenomena, particularly those affecting telephony, transmission characteristics, existing types of coaxial cable, and the problems associated with laying and joining such cables, fault clearance and the S.A.C.M. echo meter noted in 142 of February (Couanault and Herreng).

621.392.26† 3035
**Waveguides**—R. Malvano. (*Ricerca Sci.*, vol. 18, pp. 1595–1612; November and December, 1948.) Transmission theory with special reference to waveguides with dielectric inserts.

621.392.26† 3036
**On the Theory of the Excitation of Radio Wave Guides**—G. V. Kisunko. (*Compt. Rend. Acad. Sci.* (URSS), vol. 51, pp. 199–202; January 30, 1946. In English.) Formulas are derived for the field due to conductors with arbitrary current distribution and of arbitrary configuration within the waveguide.

621.392.26† 3037
**Reflection Cancellation in Waveguides**—L. Lewin. (*Wireless Eng.*, vol. 26, pp. 258–264; August, 1949.) A tapered section with uniform variation is commonly used to provide a smooth transition between waveguides of different cross-sections. For freedom from reflections, the length $l$ of the tapered section should be as great as possible, and must exceed $\lambda/2$. Minima of total reflection occur when $l=n\lambda/2$, and maxima when $l=(2n+1)\lambda/4$, $n$ being an integer. The case of small-angle tapers is discussed, with special reference to the diaphragm method of reflection compensation. The field-fitting method yields results which can be generalized and are applied to the general double taper.

621.392.26† 3038
**Experimental Investigation of the Reflections produced in a Waveguide by any Dielectric**—L. R. Noriega. (*Rev. Telecomun.* (Madrid), vol. 3, pp. 2–10; June, 1948.) Verification of theory developed by L. W. Holmboe in a thesis entitled "Reflections produced at the Junction of Two Rectangular Waveguides, one filled with a Single Dielectric and the other with Two Dielectrics."

621.392.26† 3039
**Notes on the Excitation of Electromagnetic Waves in Cylindrical Metal Waveguides**—A. Colino. (*Jour. Appl. Phys.*, vol. 20, pp. 576–577; June, 1949.) Starting from Maxwell's equations, general formulas applicable to cylindrical waveguides of any cross-section are derived. These formulas are of simple structure and for the case of a waveguide of circular cross-section excited by an antenna on the axis result in a formula identical with one given by Schelkunoff. For the original version (in Spanish) see *Rev. Telecomun.* (Madrid), vol. 3, pp. 34–37; June, 1948.

621.392.26†:621.396.611.4 3040
**The Analogies between the Vibration of Elastic Membranes and the Electromagnetic Fields in Guides and Cavities**—E. C. Cherry. (*Proc. IEE* (London), Part III, vol. 96, pp. 346–359; July, 1949. Discussion, pp. 358–360.) Detailed relations are shown between the fields in guides and cavities, and the vibrations of elastic sheets having similar boundaries. Only one of the two sets of electromechanical analogies commonly applied to circuits such as transmission lines and filters is applicable to distributed systems. In this, velocity corresponds to voltage (or E-vector) and force to current (or magnetic H-vector). Mass corresponds to capacitance (or $\kappa$) and elastic constant to inverse inductance (or $1/\mu$). A study of membrane vibrations may assist in the design of microwave components and in the derivation of new selective network forms

621.392.26†:621.396.67 3041
**Electromagnetic Radiation from Waveguides and Horns**—L. Lewin. (*Nature* (London), vol. 164, p. 311; August 20, 1949.) The method of Levine and Schwinger (1845 of 1948) for analyzing the acoustic radiation from circular pipes is applied to the case of em radiation from rectangular waveguides.

621.392.26†:621.396.67 3042
**The Electromagnetic Horn: Parts 1 and 2**—W. D. Oliphant. (*Electronic Eng.* (London), vol. 21, pp. 255–258 and 294–299; July and August, 1949.) A survey paper, in which much of the information is abstracted from the 16 references given. Basic theory, design principles, and experimental results are discussed, with special reference to rectangular waveguides and the sectoral horn.

621.392.26†:621.396.67 3043
**Transmission-Line Characteristics of the Sectoral Horn**—H. S. Bennett. (Proc. I.R.E., vol. 37, pp. 738–743; July, 1949.) The sectoral horn is considered as one component of a microwave transmission system. Equivalent network functions are derived and plotted, the sectoral horn being regarded as a nonuniform transmission line. The physical significance of the derived normalized functions is discussed.

621.392.26†:621.396.67 3044
**Laws of Potential Distribution along Slits [slots]**—J. N. Feld. (*Compt. Rend. Acad. Sci.* (URSS), vol. 55, pp. 407–410; February 20, 1947. In English.) Approximate formulas, applicable to narrow radiating slots in waveguides, are derived.

621.392.43.012.3 3045
**High-Frequency Transmission Line Chart**—P. R. Clement (*Electronics*, vol. 22, pp. 104–105; August, 1949.) Determination of input impedances and matching-stub dimensions is simplified by means of a chart in which straight lines are used instead of curves as in circle or Smith diagrams.

621.396.67 3046
**The Measurement and Interpretation of Antenna Scattering**—D. D. King. (Proc. I.R.E., vol. 37, pp. 770–777; July, 1949.) The significance of scattering and back-scattering cross-sections in terms of antenna current distribution is considered, with particular reference to the influence of antenna load impedance on the magnitude and directional pattern of the scattered radiation. A method of measurement, which uses the standing waves set up by energy reflected toward the transmitter from any receiving antenna or parasite, permits direct study of the back-scattering from loaded and unloaded antennas. Approximate scattering data for several types of antenna are included.

621.396.67 3047
**Experimental Determination of the Distribution of Current and Charge along Cylindrical Antennas**—G. Barzilai. (Proc. I.R.E., vol. 37, pp. 825–829; July, 1949.) Using a wavelength of 1.90 m, the distributions are determined for center-fed straight cylindrical antennas of diameter 29 mm and lengths $1.25\lambda$, $1.00\lambda$, and $0.50\lambda$ respectively. In some cases parasitic antennas were added. The experimental accuracy was checked by means of measurements on a coaxial line whose inner conductor had the same diameter as the antennas.

621.396.67 3048
**Radiating Surface Systems**—J. N. Feld. (*Compt. Rend. Acad. Sci.* (URSS), vol. 51, pp. 203–206; January 30, 1946. In English.) A closed metal surface of dimensions comparable with the wavelength can in certain cases, if suitably excited, compare favorably with ordinary radiating systems. Formulas are derived for the em field and the surface distribution of current for a spherical-surface antenna excited by a known current distribution along a radial conductor inside the surface. The method adopted for the solution can easily be generalized for surface antennas of arbitrary form with an arbitrary arrangement of coupling elements.

621.396.67 3049
**Diffraction Antennae with Axial Symmetry**—J. N. Feld. (*Compt. Rend. Acad. Sci.* (URSS), vol. 51, pp. 115–118; January 20, 1946. In English.) The antennas considered are obtained by cutting the surface of endovibrators. Formulas are derived and applied to the determination of the field inside and outside a sphere from which a narrow belt has been cut out, the excitation being due to a dipole at the center.

621.396.67 3050
**Excitation of a Hollow Spherical Resonator by a Dipole Placed at Its Centre**—S. M. Rytov. (*Compt. Rend. Acad. Sci.* (URSS), vol. 51, pp. 111–115; January 20, 1946. In English.) Formulas are derived for the field within the resonator and for the energy dissipation. A small hole on the equator of the sphere radiates like a magnetic dipole parallel to the equator.

621.396.67 3051
**Discone—40 to 500 Mc/s Skywire**—J. M. Boyer, (*CQ*, vol. 5, pp. 11–15, 71; July, 1949.) The evolution of the discone from a flared open-ended waveguide is traced. Dimensions and construction details are given of three models whose frequency ranges are respectively 40 to 500 Mc, 400 to 1,200 Mc, and 800 to 5,000 Mc. The last provides a means of measuring the radiation pattern of the discone by the model technique. See also 303 of March (Kandoian, Sichak, and Felsenheld).

621.396.67.016.31 3052
**A Power-Equalizing Network for Antennas**—R. W. Masters. (Proc. I.R.E., vol. 37, pp. 735–738; July, 1949.) A bridge type of network which causes equal power to be delivered to two load impedances whose product is a predetermined real constant. The input impedance of the bridge is practically independent of suitably paired load-impedance values over a considerable band of frequencies. Application to the design of television broadcast antennas is indicated, examples are given, and power loss is discussed.

621.396.671 3053
**On the Theory of the Radiation Patterns of Electromagnetic Horns of Moderate Flare Angles**—C. W. Horton. (Proc. I.R.E., vol. 37, pp. 744–749; July, 1949.) A method attributed to Schelkunoff for the computation of radiation patterns is considered. For the case of transverse electric waves in a waveguide or horn of moderate flare angle, the radiation pattern is calculated in terms of two definite integrals. These integrals are evaluated for rectangular, circular, and semicircular horns for some common modes of vibration. Experimental results are in agreement with theory.

621.396.671 3054
**The Radiation Resistance of Linear Aerials**—A. A. Samarski and A. N. Tikhonov. (*Zh. Tekh. Fiz.*, vol. 19, pp. 792–803; July, 1949. In Russian.) The reactive component of the radiation resistance is calculated for a given current distribution. This component remains finite only in the case of a tuned dipole.

621.396.671 3055
**The Transmitter Dipole**—J. Müller-Strobel and J. Patry. (*Schweiz. Arch. Angew. Wiss. Tech.*, vol. 14, pp. 306–314; October, 1948.) Theory previously given (1334 of 1947) is applied to the calculation of the radiation impedance of vertical wire antennas with and without resistance losses. A practical formula is derived and its accuracy checked by measurements on a balloon-supported antenna. The discrepancies between theory and experiment can be easily explained. The problem of antenna resonance can be solved by means of the accurate formula, but in most cases a simple relation can be used.

621.396.671 3056
**Evaluation of the Gain of a Microwave Radiating System**—F. Bosinelli. (*Ricerca Sci.*, vol. 18, pp. 1009–1015; August and September, 1948.) For an antenna with a parabolic reflector the gain $G$ is given approximately by the formula $G=4\pi I_1^2/\lambda^2 I_2$, where $I_1$ and $I_2$ are integrals involving the field distribution over the aperture of the reflector. Particular distributions are considered and a curve is given showing the diminution in gain for parabolic distributions more or less accentuated.

621.396.671 3057
**Gain of Aerial Systems**—D. A. Bell. (*Wireless Eng.*, vol. 26, pp. 306–312; September, 1949.) The maximum gain of an antenna of given aperture depends on the phase distribution of the illumination of the aperture. Three cases are considered, in order of increasing gain: (a) uniform-phase radiators (broadside arrays and "optical" radiators), (b) radiators, with effective phase-shift of $\pi$ (end-fire antennas of all kinds), and (c) antennas with closely-spaced phase reversals (high-gain short antennas). See also 302 of February (Woodward and Lawson).

621.396.677 3058
**Path-Length Microwave Lenses**—W. E. Kock. (Proc. I.R.E., vol. 37, pp. 852–855; August, 1949.) Baffle plates extend parallel to the magnetic vector, and are suitably tilted or bent to force the waves to follow a longer path. The plate array is shaped to correspond to a convex lens. Advantages over other types of metallic lens are: broader-band performance, greater simplicity, and less severe tolerances. See also 2176 of 1948.

621.396.677:621.396.93 3059
**Direction-Finding Site Errors at Very High Frequencies**—Hopkins and Horner. (*See* 3145.)

## CIRCUITS AND CIRCUIT ELEMENTS

621.3.011.2 3060
**Impedance of Composite Conductors**—(*Wireless Eng.*, vol. 26, pp. 267–275; August, 1949.) Schelkunoff's theorem for calculating this impedance (435 of 1935) is developed to derive useful working formulas. The theorem can be deduced by an extension of a method devised by Howe. Simplifications of the formulas have been made in the case of coaxial tubular conductors, where the radii of the conductors are electrically large and the curvature may be neglected.

621.3.016.35 3061
**A New Harmonic Method for Studying the Stability of Linear Systems**—Demontvignier and Lefèvre. (*See* 3127.)

621.3.087.4:551.510.535 3062
**New Equipment for the Systematic Recording of Ionospheric Echoes**—A. Bolle. (*Ann. Geofis.*, vol. 1, pp. 164–174; April, 1948.) Circuit details and description of apparatus with which the band 2.5 to 20 Mc is swept at 3-minute intervals. As in the equipment described by Sulzer (2983 of 1946) the v.f.o. controls both the frequency of the transmitter and that of the heterodyne stage of the receiver, the frequency being varied periodically by means of an electric motor driving gearing attached to a variable capacitor. Peak pulse power is about 20 kW at the lower frequencies.

621.314.2:621.396.611.33/.34 3063
**A Design for Double-Tuned Transformers**—J. B. Rudd. (*Jour. Brit. I.R.E.*, vol. 9, pp. 306–316; August, 1949.) The term "transformer" is used in the broad sense to include networks consisting of a pair of *L-C* circuits with either inductive or capacitive coupling. A

method is described of designing such transformers to provide uniform power transmission over a given frequency range; the insertion-loss curve is then approximately symmetrical when plotted on a linear frequency scale. The frequency variable used in the design equations allows a common representation of both inductively and capacitively coupled transformers. The extent of the uniform-transmission band and the transformation ratios possible with various types of coupling are discussed. Charts are presented which simplify the design procedure. Practical circuits satisfying specified conditions are given. See also 2177 of 1948 (Rideout).

Reprinted from *Proc. I.R.E.* (Australia), vol. 10, January, 1949.

621.314.3† 3064

**An Analysis of Magnetic Amplifiers with Feedback**—D. W. Ver Planck, M. Fishman, and D. C. Beaumariage. (PROC. I.R.E., vol. 37, pp. 862–866; August, 1949.) Full paper; summary noted in 2448 of October

621.314.3† 3065

**The Transductor, D.C. Pre-Saturated Reactor, with Special Reference to Transductor Control of Rectifiers**—U. Lamm. (*Acta Polyt.* (Stockholm), no. 17, 215 pp.; 1948. In English.) Fundamental principles are outlined and various methods of using transductors for regulation and control purposes are described. Similarity laws for the practical design of a series of transductors from measured values for one unit of the series are derived. A theory of transductor-controlled multiphase rectifiers is developed. Static and dynamic conditions are treated and general equations for rapid calculation of transductor-regulator parameters are derived. Experimental results confirm the theory.

621.316.313 3066

**Electrical Network Analyzers for the Solution of Electromagnetic Field Problems: Parts 1 and 2**—K. Spangenberg, G. Walters, and F. Schotts. (PROC. I.R.E., vol. 37, pp. 724–729 and 866–872; July and August, 1949.) 1948 IRE Convention paper noted in 2475 of 1948. Discussion of the design and construction of two analyzers for solving the wave equation in two-dimensional axially-symmetric cylindrical co-ordinates and in rectangular co-ordinates. The use of these analyzers is also considered for determining various modes of concentric lines, waveguides and resonators, field-strength distributions, resonant frequencies of cavities, etc.

621.316.8:621.396.822 3067

**Noise from Current-Carrying Resistors 20 to 500 kc/s**—R. H. Campbell, Jr., and R. A. Chipman. (PROC. I.R.E., vol. 37, pp. 938–942; August, 1949.) The dc noise voltage for some resistors has fluctuations much larger than those characteristic of thermal noise. This effect was investigated experimentally for solid carbon-composition, metallized palladium film, and pyrolitic-carbon resistors, for resistances from 1 to 30 kΩ and currents from 1 to 10 mA. The fluctuations are large when current is first applied to a resistor, before its resistance reaches an equilibrium value at a higher temperature. The effect is thus analogous to the Barkhausen magnetization effect, but cannot as yet be correlated with other factors.

621.316.86 3068

**Thermistors**—G. Pierry. (*Toute la Radio*, vol. 16, pp. 240–242; September, 1949.) A short account of different types, their properties and uses.

621.317.35 3069

**On Some Properties of Signals with Limited Spectra**—J. Oswald. (*Compt. Rend. Acad. Sci.* (Paris), vol. 229, pp. 21–22; July 4, 1949.) Every signal function $x(t)$ whose corresponding Fourier function $X(f)$ is zero outside a finite interval $(-f_1, f_1)$ can be developed in a series of orthogonal functions. The equidistant ordinates $x_n$ completely determine such a signal; they are the components of a vector of the Hilbert subspace defined by the segment $(-f_1, f_1)$ in the space $(f)$ derived from the space $(t)$ by the Fourier unitary transformation. All the parameters of the signal $x(t)$ can be expressed in terms of the coefficients $x_n$ and all the transformations of $x(t)$ by linear operators can be studied equally well by means of these coefficients. Examples are given.

621.318.572 3070

**New Design for a Secondary-Emission Trigger Tube**—C. F. Miller and W. S. McLean. (PROC. I.R.E., vol. 37, pp. 952–954; August, 1949.) 1948 IRE National Convention paper. A triode input section produces a primary electron beam which impinges on a dynode to produce secondary electrons. These are collected by two different output elements which may be used separately or as a unit. A dynode surface having long life and stability is described. Suggested applications include its use as a relaxation oscillator, multivibrator, pulse inverter, triangular-wave generator, and dynatron. See also 1567 of 1942 (Skellett).

621.318.572 3071

**Admittance of the 1B25 Microwave Switching Tube**—R. W. Engstrom and A. R. Moore. (PROC. I.R.E., vol. 37, pp. 879–881; August, 1949.)

621.319.4:621.315.614 3072

**Paper Capacitors using Chlorinated Liquid Impregnants**—C. G. Farley. (PROC. I.R.E. (Australia), vol. 9, pp. 13–17; July, 1948. Discussion, pp. 17–18.) Trends in the development and use of synthetic impregnants are discussed, the characteristics of chlorinated naphthalene, chlorinated diphenyl, and natural impregnating compounds such as castor oil are compared, and the physical and electrical properties of capacitors impregnated with pentachlorodiphenyl are tabulated and discussed.

621.392 3073

**Bridged Reactance-Resistance Networks**—G. R. Harris. (PROC. I.R.E., vol. 37, pp. 882–887; August, 1949.) 6-arm, 6-element *R-C* bridged networks are considered. Six symmetrical structures exist having the infinite attenuation property of the parallel-T network. The duality of certain pairs of these structures is demonstrated.

621.392 3074

**Effective and Circuit Band-Widths**—W. J. Kessler. (*Elec. Eng.*, vol. 68, p. 590; July, 1949.) Summary only. The effective bandwidth of any network of maximum response A is defined as the bandwidth of an equivalent network whose response is A throughout the transmission band, provided the noise powers developed across the output terminals of the two networks are equal for the same noise-signal input. The term "circuit bandwidth" is reserved to specify the selectivity or frequency-discriminating properties of a network. The effective bandwidth is equal to the area under the squared response curve divided by the square of the maximum response. For a single elementary *L-C* network the ratio of effective to circuit bandwidth (3-db attenuation) is equal to $\pi/2$. This ratio approaches 1.07 as the number of such elementary circuits in cascade increases and approaches unity as the response curve approaches a rectangular form.

621.392 3075

**The Gyrator, a New Circuit Element**—H. Feigs. (*Funk. und Ton.*, vol. 3, pp. 459–465; August, 1949.) A shortened version of Tellegen's recent work (980 of May and 2745 of November).

621.392 3076

**Miller Effect**—"Cathode Ray." (*Wireless World*, vol. 55, pp. 307–312; August, 1949.) A step-by-step resolution of some of its paradoxes for resistive and for reactive loads.

621.392:517.433 3077

**Operational Approach to Nonlinear Circuit Analysis**—G. H. Cohen. (*Jour. Frank. Inst.*, vol. 247, pp. 573–581; June, 1949.) The operational method can be extended to nonlinear-circuit problems by first expanding the expression for the unknown variable $i$ in a power series of the driving function $e$. Each term of the series represents a component of the total current. Each component is an operational expression for a linear differential equation involving the current component $i_r$ to the first power, the impedance $C_r$ corresponding to this current component, and the $r$th power of the driving voltage. The nonlinearity is thus shifted from the unknown dependent variable $i$ to the known independent variable $e$, making it possible to find and solve the transformed equations for each current component.

621.392.4 3078

**Constant-Phase-Shift Networks**—R. O. Rowlands. (*Wireless Eng.*, vol. 26, pp. 283–287; September, 1949.) To every phase-shift network there corresponds an attenuation network whose attenuation is directly related to the phase shift of the first network. This attenuation network, being easier to design, is designed first, and from its parameters those of the phase-shift network are deduced.

621.392.4:621.3.015.3 3079

**The Energy of a Passive Linear Two-Terminal Network in the Transient Regime**—M. Abele. (*R. C. Accad. Naz. Lincei*, series 8, vol. 1, pp. 1321–1324; December, 1946. In Italian. Reprint.) General treatment for the case where the applied emf is a periodic function of time. This is extended to the case of a nonperiodic emf of short duration, by considering it as a single period of a periodic emf.

621.392.43 3080

**Compact Antenna-Coupling Device**—S. Wald. (*Radio and Telev. News, Radio-Electronic Eng. Supplement*, vol. 12, pp. 7, 30; March, 1949.) Description, with illustrations, of a continuously variable inductor with two independent tappings which can be used for antenna tuning and matching over a wide frequency range.

621.392.5:621.3.015.3 3081

**Transients in the Low-Pass Filter**—G. Newstead and D. L. H. Gibbings. (*Proc. IEE* (London), part III, vol. 96, pp. 264–268; July, 1949.) Formulas for the termination current are given and plotted for various impulsive voltage inputs. Limitations of the usual approximate treatments are discussed. A solution is obtained for a uniformly dissipative low-pass filter terminated in a resistance of $\sqrt{(L/C)}$.

621.392.5:681.142 3082

**Mercury Delay Line Memory Using a Pulse Rate of Several Megacycles [per second]**—I. L. Auerbach, J. P. Eckert, Jr., R. F. Shaw, and C. B. Sheppard. (PROC. I.R.E., vol. 37, pp. 855–861; August, 1949.) The possible pulse rate has been effectively doubled by means of the pulse envelope system of representing data. The control of signals at high pulse rates has been achieved by means of crystal gating circuits. A multichannel memory using a single pool of mercury has simplified mechanical construction and temperature control, and has reduced the size. Intelligence can be transmitted and received by the memory system described at $5\times10^6$ binary digits per second.

621.392.52 3083

**A Valve-Assisted Filter for Audio Frequencies**—J. D. Storer. (*Jour. Brit. I.R.E.* vol. 9, pp. 268–275; July, 1949.) The filter

combines the function of voltage limiting and wave filtering, and consists of a flip-flop oscillator which is inoperative until triggered. Its oscillation frequency is controlled by that of the triggering voltage, which is developed across a reactive circuit. Characteristics are summarized and circuit diagrams illustrating the applications of the filter are given.

621.392.52 3084
**RC Filter Networks**—A. Sabbatini. (*Poste e Telecomun.*, vol. 16, pp. 83–88; March, 1948.) Detailed analysis of (a) a bridge-type circuit for phase variation due to Scott (1802 of 1938), (b) a resonance potential divider due to Willoner and Tihelka (*Hochfrequenztech. u. Elektroakust.*, vol. 61, p. 48; February, 1944), (c) a R-C amplification stage, and (d) R-C low-pass and high-pass filters.

621.392.52:621.395.625.2 3085
**Crossover Filter for Disk Recording Heads**—H. E. Roys. (*Broadcast News*, no. 55, pp. 20–23; June, 1949.)

621.395.665.1 3086
**Contrast Expansion**—G. Mitchell and J. G. White. (*Wireless World*, vol. 55, pp. 315–316; August, 1949.) Comment on 2171 of September (Wheeler).

621.396.611.1 3087
**Iterative Impedance and Resonance Curve of Symmetrical Homogeneous Recurrent Circuit**—P. Kalantarov and L. Zeitlin. (*Compt. Rend. Acad. Sci.* (URSS), vol. 51, pp. 281–284; February 10, 1946. In English.)

621.396.611.1 3088
**On Approximate Integration for Oscillatory Systems with One Degree of Freedom**—V. V. Kazakevitch. (*Compt. Rend. Acad. Sci.* (URSS), vol. 51, pp. 107–110; January 20, 1946. In French.) A method enabling the building-up process, the form and the period of the oscillations of a system to be determined for the case where there are no external perturbations.

621.396.611.1 3089
**Resonance Phenomena in Homogeneous Symmetrical Recurrent Circuits**—P. L. Kalantarov and L. A. Zeitlin. (*Compt. Rend. Acad. Sci.* (URSS), vol. 51, pp. 357–360; February 20, 1946. In English.)

621.396.611.1:621.3.015.3 3090
**A Note on the Transient Response of an Oscillatory Circuit with Recurrent Discharge**—A. M. Hardie. (*Phil. Mag.*, vol. 40, pp. 748–759; July, 1949.) Such circuits were discussed by Wilkinson (864 of 1948). The general characteristics and duration of the transient are here considered and illustrated graphically. The transient response to a voltage step-function is calculated. Account is also taken of circuit losses.

621.396.611.4 3091
**Approximate Integration of Maxwell's Equations [for stationary e.m. fields] Inside a Cavity Resonator**—M. Abele. (*Atti Accad. Sci. Torino*, vols. 81 and 82, pp. 159–167; 1945 and 1947. Reprint.) Calculations applied in 3823 of 1947.

621.396.611.4 3092
**Nodal Planes in a Perturbed Cavity Resonator: Parts 2 and 3**—K. F. Niessen. (*Appl. Sci. Res.*, vol. B1, pp. 251–260 and 284–298; 1949.) A mathematical paper. The resonator considered is rectangular and has one movable wall. In part 1 (994 of May) a vibration without nodal planes was considered. In part 2 a vibration with a single nodal plane (a) perpendicular, (b) parallel to the movable wall is discussed. Part 3 is concerned with the case where the vibration in the unperturbed resonator has two nodal planes, one perpendicular and the other parallel to the movable wall. The perturbed field is determined in each case. See also 1330 of June.

621.396.611.4:621.392.26† 3093
**The Analogies between the Vibration of Elastic Membranes and the Electromagnetic Fields in Guides and Cavities**—Cherry. (*See* 3040.)

621.396.615 3094
**Study of the Transmission-Line Oscillator with Ordinary Valves**—R. de Magondeaux. (*Radio Franç.*, nos. 6, 7, and 8, pp. 21–24 and 13–19; June, July, and August, 1949.) Theory of the operation of simple oscillators for wavelengths between 4 and 40 cm. Relations between the various currents and voltages are shown graphically, and output efficiency and radiated power are considered. Such oscillators are particularly suitable for demonstration purposes.

621.396.615:621.317.083.7 3095
**Transistor Oscillator for Telemetering**—F. W. Lehan. (*Electronics*, vol. 22, pp. 90–91; August, 1949.) An oscillator used for FM of the telemetering transmitter. Advantages are noted. Variation of frequency with transistor temperature is undesirable. Temperature compensation is being investigated.

621.396.615.029.64:621.316.726 3096
**An Analysis of the Sensing Method of Automatic Frequency Control for Microwave Oscillators**—E. F. Grant. (Proc. I.R.E., vol. 37, pp. 943–951; August, 1949.) Circuits using a simple cavity resonator for the stable element and either FM of the controlled oscillator or modulation of the cavity resonance frequency are analyzed to obtain effective discriminator curves which give a null output for the average cavity resonance frequency. The complete afc loop gain, the best method of decreasing the pulling of the oscillator frequency by the cavity, and the pulling of the cavity frequency by a variable-susceptance load are discussed.

621.396.615.17 3097
**Pulsed Stimulator Aids Medical Research**—L. A. Woodbury, M. Nickerson, and J. W. Woodbury. (*Electronics*, vol. 22, pp. 84–85; August, 1949.) A multivibrator-controlled constant-current pulse generator. Pulse duration, 0.025–1.5 ms. Repetition rate, 0.1–1,000 pulses per second. Output continuously variable from zero to over 1,000 mA.

621.396.615.17:621.317.755:621.397.6 3098
**Television Time Base Linearisation**—A. W. Keen. (*Electronic Eng.* (London), vol. 21, pp. 195–198, 223; June, 1949.) Linearity correction by the integration method is discussed. A simple sawtooth generator consisting of a series *R-C* circuit connected across a source of constant dc voltage, with a discharge device connected across the capacitor, has an exponential output when the discharger is inoperative. An additional *R-C* circuit can be associated with the generator so that a suitable proportion of the output of the second circuit is added to that of the generator to make the resultant essentially linear. Details of practical correction circuits are discussed.

621.396.615.17:621.397.645.001.4 3099
**Video Amplifier Testing—Using a Square-Wave Generator**—T. B. Tomlinson. (*Electronic Eng.* (London), vol. 21, pp. 204–208; June, 1949.) The square-wave generator described is of a conventional type using a multivibrator whose output is clipped by means of a tube operating near cut-off. The output of the squaring tube is fed into a cathode follower to prevent waveform deterioration when working into a considerable load-capacitance. Modifications of the square wave by the more common types of distortion are shown and discussed.

621.396.615.18 3100
**High-Ratio Multivibrator Frequency-Divider**—M. Silver (*Radio and Telev. News, Radio-Electronic Eng. Supplement*, vol. 13, pp. 7–9; 20; July, 1949.) Theory and description of a stable circuit capable of division ratios as high as 300:1. Component details are furnished of a circuit giving a 15-kc output from a 4.5-Mc input; only two 6SN7 double triodes are required.

621.396.645 3101
**High-Quality Amplifier: New Version**—D. T. N. Williamson. (*Wireless World*, vol. 55, pp. 282–287; August, 1949.) Modifications of an earlier model (2715 of 1947) with construction data and details of the necessary adjustments to give linear response with low harmonic and intermodulation distortion. The impedances for various connections of the output transformer secondary are tabulated. Negative feedback and the prevention of instability are discussed.

621.396.645 3102
**Some Aspects of Cathode-Follower Design at Radio Frequencies**—F. D. Clapp. (Proc. I.R.E., vol. 37, pp. 932–937; August, 1949.) Simple design charts, derived by approximations which are applicable over a wide range of frequency and of circuit parameters, for determining at hf the circuit gain, the gain phase angle, the input impedance in resistive and reactive components, the maximum allowable input signal voltage, etc. Various circuit changes which reduce or eliminate the undesirable effects of the grid/cathode capacitance are discussed.

621.396.645 3103
**A Wide-Band Amplifier (100 cls to 20 Mcls)**—J. C. Plowman. (*Electronic Eng.* (London), vol. 21, pp. 338–340; September, 1949.) A two-stage, filter-coupled amplifier with cathode-follower output, giving an over-all gain of 38 db in the frequency range 100 cps-16 Mc, with a slight falling off at higher frequencies.

621.396.645:621.3.015.3 3104
**Design of Optimum Transient Response Amplifiers**—P. R. Aigrain and E. M. Williams. (Proc. I.R.E., vol. 37, pp. 873–879; August, 1949.) The method described is derived from operational analysis using Laplace transforms. It is based on transient considerations, and not derived from steady-state theories. Applications to video amplifiers, symmetrical bandpass amplifiers, and unsymmetrical bandpass amplifiers with low-level modulation are discussed.

621.396.645:621.3.015.3 3105
**Transient Response of Wideband Amplifiers**—W. E. Thomson. (*Wireless Eng.*, vol. 26, pp. 264–266; August, 1949.) A suitable 2-terminal load for a wideband amplifier stage is the "infinite-order critically-damped load" discussed in 671 of 1947. This load gives the fastest unit-step response without overshoot. Any desired approximation to the compensating reactance can be obtained by using one of a certain series of networks. The second member of this series consists of one inductor and one capacitor, and gives a result adequate for most practical purposes.

621.396.645:621.396.615.142 3106
**Application of Velocity-Modulation Tubes for Reception at U.H.F. and S.H.F.**—M. J. O. Strutt and A. van der Ziel. (Proc. I.R.E., vol. 37, pp. 896–900; August, 1949.) Discussion on 1890 of 1948.

621.396.645:621.396.813 3107
**On Criteria for the Permissible Non-Linear Distortion of Amplifiers**—V. F. Schut and C. W. Kosten. (*Appl. Sci. Res.*, vol. B1, pp. 261–267; 1949.) The sum of the amplitude of the second harmonic and twice that of the third harmonic appears to be a good criterion. For reproduction of moderate quality this sum should not exceed 24 per cent of the amplitude of the fundamental.

621.396.645.029.3:621.385.3 3108
**A Low-Noise [audio] Input Tube**—Knight and Haase. (*See* 3303).

621.396.645.029.4/.5 3109
**On the Amplification of the Low Frequencies in Wide-Band Amplifiers**—W. Dillenburger. (*Funk. und Ton.*, vol. 3, pp. 423–428; August, 1949.) An extension of the frequency band towards the lower frequencies is made possible by a circuit which increases the effective coupling time-constant between two amplifier stages. The effect of the time-constant of the cathode circuit can be completely compensated with a suitably designed anode circuit, so that the frequency characteristic of the amplification is determined only by the coupling member for the stage. A design is given in which the effect of the filter capacitors of the supply unit on the amplitude characteristic at low frequencies is reduced, as well as the kipp oscillations which may occur with more than two stages.

621.396.645.37 3110
**Feedback Amplifier Design**—H. Mayr. (*Wireless Eng.*, vol. 26, pp. 297–305; September, 1949.) Discussion of design when the response curve is pre-selected and has no spurious peaks. A simple general equation is derived which gives the frequency response of the amplifier with feedback, if the response of the amplifier without feedback and the frequency characteristics of the feedback network are known. The special case of amplifiers with up to four stages of resistance-capacitance or tuned-circuit coupling, with constant feedback and equal center frequencies for all stages is considered; design formulas are given.

621.396.645.371 3111
**Negative Feedback Amplifiers**—T. S. McLeod. (*Wireless Eng.*, vol. 96, pp. 312–313; September, 1949.) Comment on 2768 of November (Brockelsby).

621.396.69 3112
**Circuit Techniques for Miniaturization**—P. G. Sulzer. (*Electronics*, vol. 22, pp. 98–99; August, 1949.) Controlled positive feedback between stages can often be used to avoid the necessity for bulky circuit components, such as cathode and screen by-pass capacitors and video-amplifier compensating inductors, with corresponding reduction in both size and cost.

621.397.62 3113
**Transit-Time Effects in Television Front-End Design**—H. M. Watts. (*Electronics*, vol. 22, pp. 158, 170; August, 1949.) The effect of transit-time is to add about 4 to the noise figure near the frequency where the transit-time loading conductance equals the desired input conductance. Transit-time effects tend to level out the differences between various circuit combinations, so that as the frequency increases, the reduction of noise from sources other than transit-time decreases in importance

621.397.645 3114
**Television Stabilizing Amplifier**—J. L. Schultz. (*Radio and Telev. News, Radio-Electronic Eng., Supplement*, vol. 12, pp. 12–15, 28; May, 1949.) Full circuit details and special features of a unit which can be used in the studio or at the transmitter as a picture-line amplifier, or as a program amplifier for a line or radio link.

621.396.69 3115
**Components Handbook [Book Review]**—J. F. Blackburn (Ed.). Publishers: McGraw-Hill Book Co., New York, 1949. 626 pp., $8.00. (*Electronics*, vol. 22, pp. 212, 214; August, 1949.) Vol. 17 of the M.I.T. Radiation Laboratory series. Only components developed by or under the sponsorship of the Radiation Laboratory or of primary importance in its work are covered thoroughly, and several important classes of these components have been left out. Most of the data included have not been published before.

## GENERAL PHYSICS

535.3 3116
**Quantitative Evidence for Boundary-Layer Waves in Optics**—H. Maecker. (*Ann. Phys.* (Lpz.), vol. 4, pp. 409–431; June 25, 1949.) The existence of such waves is established. Experimental results are in good agreement with Ott's theory (18 of 1943 and 3117 below). The connection between optical boundary-layer radiation and the ray shift in total reflection described by Goos and Hänchen (*ibid.*, vol. 1, p. 333; 1947.) is examined.

535.3 3117
**On the Reflection of Spherical Waves**—H. Ott. (*Ann. Phys.* (Lpz.), vol. 4, pp. 432–440; June 25, 1949.) Previous calculations for the Schmidt "head wave" [Kopfwelle] for the vertical dipole (18 of 1943) are extended to dipoles with any direction whatever. See also 3116 above.

535.42 3118
**On the Theory of Diffraction**—W. Franz. (*Z. Phys.*, vol. 125, pp. 563–596; March 15, 1949.) An approximation method is given for the solution of acoustical and optical diffraction problems, which includes Kirchhoff's diffraction theory as a special case of the first approximation. While Kirchhoff's method is concerned only with diffraction at a black screen, with the present method reflection and refraction can also be treated and its application is not limited to short wavelengths. The first and second approximations are applied to the case of the semi-infinite plane and the higher approximations to that of the small sphere.

535.42 3119
**An Asymptotic Treatment of Diffraction Problems**—N. G. van Kampen. (*Physica's Grav.*, vol. 14, pp. 575–589; January, 1949. In English, with French summary.) An asymptotic development of Kirchhoff's integral for $\lambda \to 0$ is given. The first term corresponds to geometrical optics, and includes intensity and phase. The other terms are the corrections for diffraction. The diffraction at the edge of the opening is treated quasi-geometrically. The theory is applied to optical systems, and the third-order aberration constants are calculated.

537.291+538.691]:537.525.92 3120
**Electron Flow in Curved Paths under Space-Charge Conditions**—B. Meltzer. (*Proc. Phys. Soc.* (London), vol. 62, pp. 431–437; July 1, 1949.) A general, synthetic method of obtaining rigorous solutions of steady electron flow subject to space-charge forces is presented. The solutions are not obtained for given boundary conditions, but the boundary conditions are deduced from the solutions. Two examples of such solutions, involving strongly curved two-dimensional electron trajectories, are given; the method is in principle capable of giving the solutions of all possible electron flow patterns in three dimensions except perhaps those involving intercrossing trajectories. It is suggested that the subject offers scope for applied mathematical research at least on the same scale as potential theory.

537.311.4 3121
**Contact Resistance and Its Variation with Current**—S. Rudeforth. (*P. O. Elec. Eng. Jour.*, vol. 42, pp. 65–69; July, 1949.) Empirical relationships have been derived for the non-linear resistance/current characteristics of specified contacts.

537.523.4 3122
**Calculation of Spark Breakdown Voltages in Air at Atmospheric Pressure**—A. Pedersen. (*Appl. Sci. Res.*, vol. B1, pp. 299–305; 1949.) Discussion of a new semi-empirical criterion for breakdown, which depends on the ion density.

538.3 3123
**The Experimental Basis of Electromagnetism: Parts 3 and 4**—N. R. Campbell and L. Hartshorn. (*Proc. Phys. Soc.* (London), vol. 62, pp. 422–429 and 429–444; July 1, 1949. Discussion, pp. 444–445.) The principles outlined in previous parts (3091 of 1947 and 1909 of 1948) dealing with the dc circuit and electrostatics are here applied to magnetism to show how the basic concepts are defined in terms of the operations performed in measuring them. The vector B is established as measurable everywhere, even within solid bodies. The vector $H$ and the scalar $\mu = B/H$ are shown to be measurable in special circumstances by means of the magnetometer and permeameter, but in general their values depend on a hypothesis, which is stated. The significant facts concerning the magnetic properties of real materials are briefly reviewed.

538.566 3124
**Diffraction of Electromagnetic Waves by a Perfectly Conducting Plane Screen**—J. P. Vasseur. (*Compt. Rend. Acad. Sci.* (Paris), vol. 229, pp. 179–181; July 18, 1949.) Copson, in his treatment of the problem, omitted from his equations a curvilinear integral which, though zero in the examples he considered, may be important in other cases. The correct solution is here given, the formulation of the equations being analogous to that of Bethe (706 of 1945).

538.569.4.029.64 3125
**Microwave Spectroscopy**—W. Gordy. (*Rev. Mod. Phys.*, vol. 20, pp. 668–717; October, 1948.) General discussion of instruments, experimental methods, spectra of gases, vapors, liquids and solids, and applications.

538.569.4.029.64+537.226.2]:546.212 3126
**Electrical Properties of Water**—J. A. Saxton. (*Wireless Eng.*, vol. 26, pp. 288–292; September, 1949.) Anomalous dispersion occurs mainly between the frequencies of $10^3$ and $10^6$ Mc. Over this interval the permittivity of water falls from 80 to 5.5. The ionic conductivity of fresh water is important only at frequencies below $10^3$ Mc, and that of sea water at frequencies below $2 \times 10^6$ Mc. The effect of anomalous dispersion on the reflection coefficient of fresh water surfaces is considered. See also 1912–1915 of 1948.

621.3.016.35 3127
**A New Harmonic Method for Studying the Stability of Linear Systems**—M. Demontvignier and P. Lefèvre. (*Rev. Gén. Élec.*, vol. 58, pp. 263–279; July, 1949.) The mathematical basis and the physical significance of the usual harmonic methods are reviewed and Nyquist's criterion of stability is generalized. The principles are explained of a new method, of very general application, which can be applied to any linear system, starting from its generalized phase diagram. Several abacs are given which enable the phase and amplitude diagrams to be traced quickly. The method is applied to the theory of the stability of servomechanisms. See also 1568 of 1948 (Rocard) and back references, for which the above U.D.C. would have been preferable.

## GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

521.15:538.12 3128
**Theory of the Relations between Gravitation and Electromagnetism and Their Astrophysical and Geophysical Applications**—A. Gião. (*Jour. Phys. Radium*, vol. 10, pp. 240–249; July and September, 1949.) Application to space-time of Codazzi's equations for a hypersurface leads to fundamental relations between gravitation and electromagnetism, when the external metric tensor of space-time is interpreted as a tensor of the em field. This interpretation is a consequence of the fundamentals of the author's unitary theory, according wo

which all the em properties of the universe are described, directly or indirectly, by the external metric tensor of space-time.

Application of general formulas to the particular case of a sphere in rotation without permanent magnetization gives an important relation between the magnetic moment and the moment of inertia, and proves that the general magnetism of large rotating bodies, such as the stars, is a fundamental consequence of their rotation. Formulas are obtained for the em field of a sphere in rotation which explain the general magnetic field of the earth both external to the surface and underneath it. The same formulas can also be applied to the permanent and periodic magnetism of stars. Codazzi's equations lead to a relation between gravitation and the es field which serves to explain both the mean es field of the earth and the maintenance of its charge. See also 1023, 1634, and 2776 of 1948.

523.72.029.63"1949.05.08":523.75 3129

**Exceptional Solar Radio Emission during 8th May 1949**—M. Laffineur and R. Servajean. (*Compt. Rend. Acad. Sci.* (Paris), vol. 229, pp. 110–112; July 11, 1949.) Records of solar radiation on a wavelength of 54.5 cm, obtained towards sunset at Meudon observatory, showed large variations of intensity, which at times exceeded 5 times that of the quiet sun. Simultaneous spectroheliosope observations revealed an intense solar eruption.

An increase in the number of atmospherics on a wavelength of 11,500 m was recorded at the same time at Bagneux, Bordeaux, Poitiers, and Rabat. A fade-out of the sw transmissions from Leipzig on 9.732 Mc and from WWV (Washington) on 15 Mc was noted at Bagneux.

A very small crochet in the record of the vertical component of the earth's magnetic field was noted at Chambon-la-Forêt observatory. This crochet coincided with a 10-second jump of 54.5-cm intensity to 4.7 times that of the quiet sun.

Phenomena probably associated with this solar activity were (a) a lowering of the critical frequency at 0400 on May 11, which was the start of a perturbation of the height of the ionized layers, particularly the $F_2$ layer, which reached an abnormal height between 0600 and 0700 on May 13; (b) a sudden drop in the value of the horizontal component of the earth's magnetic field at 0200 on May 11, and a violent magnetic storm on May 12 and 13.

550.383 3130

**The Magnetic Field within the Earth**—E. C. Bullard. (*Proc. Roy. Soc. A*, vol. 197, pp. 433–453; July 7, 1949.) A discussion on the magnetic effects of motion in the earth's core. Tidal friction, fluctuations in the rate of rotation, nutation, and the variation of latitude have negligible magnetic effects. Radioactivity of core material will greatly affect the internal field as a result of thermal convection. This field is larger and more complex than was previously believed and its existence confirms the induction theory of the origin of the secular variation. See also 381 of March.

551.510.535 3131

**The Ionosphere over Mid-Germany in June 1949**—Dieminger. (*Fernmeldetech. Z.*, vol. 2, p. 244; August, 1949.) Continuation of 2792 of November. A whole series of weak and medium disturbances of the $F_2$ layer were observed during the month.

551.510.535 3132

**Ionospheric Virtual Height Measurements at 100 kc/s**—R. A. Helliwell. (Proc. I.R.E., vol. 37, pp. 887–894; August, 1949.) A simple high-power sounding equipment is described. Results of intermittent night-time measurements of virtual height at vertical incidence are discussed. The virtual height varied between 84 km and as much as 106 km. At night the reflecting layer appears to consist of ionized clouds, in contrast to the more uniform ionization of the regular layers which affect hf waves. A rotation of the polarization of the reflected signal relative to that of the transmitted signal was observed.

551.510.535:525.624:550.384.4 3133

**Lunar Oscillations in the D-Layer of the Ionosphere**—E. V. Appleton and W. J. G. Beynon. (*Nature* (London), vol. 164, p. 308; August 20, 1949.) The daily measurements of ionospheric absorption made at Slough during the period 1943–1948, using a frequency of 2 Mc, indicate a lunar oscillation in D-layer absorption. If the D-layer electrons move up and down between levels of different electron collision frequency, the oscillation would be almost exactly out of phase with that known to exist in the higher E layer.

551.510.535:621.3.087.4 3134

**New Equipment for the Systematic Recording of Ionospheric Echoes**—Bolle. (*See* 3062.)

551.510.535:621.396.11 3135

**Correlation of Sporadic E Region Ionization over Short Distances and Comparison with Magnetic Disturbances**—V. B. Gerard. (*N.Z. Jour. Sci. Tech.*, vol. 30, pp. 27–37; July, 1948.) Simultaneous observations of sporadic-E ionization were made at points separated by distances up to 40 km, using two fixed stations and portable recording equipment. An approximately linear relationship was found between the correlation coefficient of simultaneous sporadic-E critical frequencies at two points, and the distance between the points. A method of calculating the muf for sporadic-E communication over distances up to 100 km is outlined. One observation suggests that a particular sporadic-E cloud had a diameter of 540 km and a velocity of 270 km per hour. No relationship between sporadic-E changes and changes in the earth's magnetic field could be detected. See also 3117 of 1948 (Ferrell) and 3410 of 1948 (Revirieux: Lejay).

551.524.4 3136

**The Vertical Temperature Gradient in the Lower Atmosphere under Daylight Conditions**—G. W. C. Tait. (*Quart. Jour. R. Met. Soc.*, vol. 75, pp. 287–292; July, 1949.) An empirical relationship is derived for the first 10–20 m of the atmosphere, in terms of the position of the sun and cloud cover. This relationship is independent of wind speed, and applies to reasonably level surfaces of soil or short vegetation during daylight, but does not apply to open water surfaces.

551.524.7 3137

**The Thermal Equilibrium at the Tropopause and the Temperature of the Lower Stratosphere**—R. M. Goody. (*Proc. Roy. Soc. A*, vol. 197, pp. 487–505; July 7, 1949.) Continuity of temperature at the tropopause is a necessary condition for stable transition from a state of convective equilibrium to one of radiative equilibrium.

551.594 3138

**On the Fundamental Problem of Atmospheric Electricity**—T. Schlomka. (*Z. Phys.*, vol. 125, pp. 733–738; March 5, 1949.) It is shown that Michel's theory (2086 of 1941) is untenable, since it is based on an erroneous assumption. The maintenance of the earth's negative charge requires a process continuously supplying a negative charge to the earth's surface. This, however, is not the case for unipolar induction with a rotating earth, which can only produce a static charge distribution in the atmosphere and within the earth.

551.594.5 3139

**Auroral Radiation in the 3000-Mc/s Region**—P. A. Forsyth, W. Petrie, and B. W. Currie. (*Nature* (London), vol. 164, p. 453; September 10, 1949.) Short pulses of radiation were observed on the indicator of a 3,000-Mc radar during an auroral display even when the transmitter was off. These pulses arrived in a random manner, in bursts lasting a small fraction of a second. Individual pulses lasted 1–5 μs. See also 2522 of October (Petrie, Forsyth, and McConechy).

## LOCATION AND AIDS TO NAVIGATION

621.396.9 3140

**A Forward-Transmission Echo-Ranging System**—D. B. Harris. (Proc. I.R.E., vol. 37, pp. 767–770; July, 1949.) 1949 IRE Convention paper noted in 1672 of June (No. 92). A proposed system with p.p.i. display for detecting targets such as atmospheric irregularities, which have a low reflection coefficient except at grazing incidence. Transmitter and receiver are about 100 miles apart. Microwave pulses lasting about 0.01 μs are required.

621.396.93 3141

**V.H.F. Direction Finder for Light Planes**—G. Wennerberg. (*Electronics*, vol. 22, pp. 118, 140; August, 1949.) This omni-range system provides azimuth information directly in degrees for an aircraft in any position within the line-of-sight range of the transmitting station. The frequency used is within the band 108 to 132 Mc and the system has a useful working range of 50 to 100 miles. The basic principle is the same as that of the German Sonne system; navigational information is supplied as the time difference at the receiving point between a nondirectional signal and one transmitted on a rotating beam from the same transmitter.

621.396.93 3142

**The Relative Merits of Presentation of Bearings by Aural-Null and Twin-Channel Cathode-Ray Direction-Finders**—S. de Walden and J. C. Swallow. (*Proc. IEE* (London), part III, vol. 96, pp. 307–320; July, 1949.) The visual method of bearing display is shown to be superior in nearly all respects except for its relative ineffectiveness at very low signal-to-noise ratios.

621.396.93 3143

**The Specification and Measurement of Polarization Errors in Adcock-Type Direction Finders**—W. Ross. (*Proc. IEE* (London), part III, vol. 96, pp. 269–277; July, 1949.) For instruments erected not more than about $\lambda/4$ above the ground, the "standard wave error" is the best specification of polarization error, while the "pick up ratio" for wanted and unwanted fields is appropriate for more elevated systems. The method of test using a nearby elevated transmitter is described in detail; in the frequency range 3 to 30 Mc a loop up to about 1.6 m in diameter at a distance of not less than 100 m may be used. For frequencies below 3 Mc the "local-injection" method of test may be more practicable. The performance of a direction finder is very dependent on the electrical properties of the site.

621.396.93:621.396.11 3144

**Scattering of Radio Waves by Metal Wires and Sheets**—Horner. (*See* 3237.)

621.396.93:621.396.677 3145

**Direction-Finding Site Errors at Very High Frequencies**—H. G. Hopkins and F. Horner. (*Proc. IEE* (London), part III, vol. 96, pp. 321–332; July, 1949. Discussion, pp. 340–345.) Theoretical and practical investigations are described, concerned mainly with Adcock-type direction finders. The variation in error with the position of various types of reflecting obstacle is examined and the use of error charts for locating such sources of error on a site is described. Of several practical methods suggested for locating the obstacles, two have been used with success, namely the variation of the azimuth or of the frequency of the transmitter. Methods of suppressing unwanted reflections are considered. A criterion

is suggested to express the susceptibility of a direction finder to site error, and is applied to well-known instrumental types.

621.396.932 3146

**The Design and Characteristics of Marine Radar Equipment**—A. Levin and A. C. D. Haley. (*Jour. Brit. I.R.E.*, vol. 9, pp. 202–219; June, 1949.) Discussion of the use of radar for coastal navigation and collision warning. Information made available by radar is compared with that available visually. The p.p.i. display is almost always used. The effect of meteorological phenomena on the choice of wavelength, and the limitations imposed by vessel size and the space available for the installation are considered. Experimental procedure for determining the main constants of the radar equipment is described, and typical results are discussed and illustrated.

621.396.933+629.139.83 3147

**What We Learned from the Berlin Airlift**—M. A. Chaffee and R. B. Corby. (*Electronics*, vol. 22, pp. 78–83; August, 1949.) The control of the aircraft was achieved by means of a combination of conventional radio ranges and homing beacons with appropriate airborne range receivers, long-range surveillance radar, precision landing-approach radar and vhf voice-communication equipment. The radar system used was the American CPS-5, with a range of more than 100 miles, capable of high accuracy and incorporating moving-target indication. The technique of video-mapping was also used.

621.396.933 3148

**The Course-Line Computer for Radio Navigation of Aircraft**—F. J. Gross. (PROC. I.R.E., vol. 37, pp. 830–834; July, 1949.) 1948 IRE Convention paper noted in 2524 of 1948. The range and bearing of an aircraft from a vhf omnirange station are converted into distance from destination and lateral deviation from a selected course. Circular courses may also be flown with the range station at the center.

621.396.933 3149

**Modern Air and Ground Instrumentation in America's Air Navigation Program**—D. W. Rentzel. (*Instruments*, vol. 22, pp. 492–493, 542; June, 1949.) The omni-range system provides a visual indication of the bearing of the aircraft from a fixed station. Associated distance-measuring equipment at the station and a lightweight airborne "course-line computer" enable the pilot to fly a straight course between any two selected points. Two landing aids—Instrument Landing System and Precision Beam Radar—are briefly discussed. For another account see 2236 of September (Sandretto).

621.396.9 3150

**Principles and Practice of Radar [Book Review]**—H. E. Penrose. Publishers: G. Newnes, London, 42s. (*Engineer* (London), vol. 188, p. 71; July 15, 1949.) " . . . a book for practical men rather than for theorists . . . deserves a place on any radio engineer's shelves."

621.396.9 3151

**A Textbook of Radar [Book Review]**—Staff of the Radiophysics Laboratory, Council for Scientific and Industrial Research, Australia. Publishers: Chapman and Hall, London, 1948, 579 pp., 50s. (*Proc. Phys. Soc.*, vol. 62, pp. 465–466; July 1, 1949.) The work of the wartime radiophysics team in Australia. The whole field is covered in 20 chapters by 21 contributors. The editing has been well done and in consequence there are few obscurities and few definite mistakes. It should be of value to any serious student of radio.

621.396.9 3152

**Microwaves and Radar Electronics [Book Review]**—E. C. Pollard and J. N. Sturtevant. Publishers: J. Wiley and Sons, New York, 1948, 414 pp., $5.00; Chapman and Hall, London, 30s. (PROC. I.R.E., vol. 37, p. 785; July, 1949. *Wireless Eng.*, vol. 26, p. 313; September, 1949.) The book presents to the engineer, who has had little or no experience with microwaves, the fundamental and practical aspects of microwave and radar engineering. Only a working knowledge of physics, calculus, and tube theory and practice is assumed.

621.396.9 3153

**The War History of the Radio Branch [Book Notice]**—Publishers: National Research Council of Canada, Ottawa, Report No. ERA-141, 131 pp. An account of Canadian radar research up to the end of 1945.

## MATERIALS AND SUBSIDIARY TECHNIQUES

533.56 3154

**Design Calculations for Molecular Vacuum Pumps**—R. Risch. (*Schweiz. Arch. Angew. Wiss. Tech.*, vol. 14, pp. 279–285; September, 1948.)

535.37 3155

**On the Quenching of the Luminescence of Certain ZnS–Cu and CaS–Bi Phosphors**—F. Bandow. (*Ann. Phys.* (*Lpz.*), vol. 1, pp. 399–404; October 1, 1947.)

535.37 3156

**Decay and Quenching of Fluorescence in Willemite**—F. A. Kröger and W. Hoogenstraaten. (*Physica's Grav.*, vol. 14, pp. 425–441; September, 1948. In English.)

535.37 3157

**The Influence of Temperature Quenching on the Decay of Fluorescence**—F. A. Kröger, W. Hoogenstraaten, M. Bottema, and T. P. J. Botden. (*Physica,'s Grav.*, vol. 14, pp. 81–96; April, 1948. In English.) Temperature quenching increases the rate of decay considerably. The probabilities of fluorescence transition and of radiationless transition are determined separately as functions of temperature; these two probabilities determine both the efficiency of fluorescence and the decay. Results favor the theory of Mott and Seitz for the radiationless process.

535.371.07:621.385.832 3158

**The Physics of Cathode Ray Tube Screens**—G. F. J. Garlick. (*Electronic Eng.* (London), vol. 21, pp. 287–291; August, 1949.) Discussion of the characteristics of screen materials, and of the mechanism of processes involved in screen luminescence.

538.22 3159

**Magnetic Properties of Ferrites; Ferrimagnetism and Antiferromagnetism**—L. Néel. (*Ann. Phys.* (Paris), vol. 3, pp. 137–198; March and April, 1948.) Comprehensive discussion, with detailed theory and comparison with experimental results.

538.22 3160

**Dispersion and Absorption in Magnetic Ferrites at Frequencies above One Mc/s.**—J. L. Snoek. (*Physica,'s Grav.*, vol. 14, pp. 207—217; May, 1948.) The contribution of the Bloch boundaries to magnetization is neglected at frequencies above 1 Mc. For pure and unstrained polycrystalline aggregates of cubic crystals, the critical frequency $\omega_0$ and the initial susceptibility $\chi$ satisfy the equation

$$\omega_0\chi = 3/2|g|M$$

where $g = e/mc = 1.76\times10^8$, $M$ is the magnetic moment per cm³, and the damping is assumed small. Internal stresses tend to increase the losses at lower frequencies.

538.221 3161

**Tentative Theory of the Magnetic Properties of Rhombohedric Sesquioxide of Iron**—L. Néel. (*Ann. Phys.* (Paris), vol. 4, pp. 249–268; May and June, 1949.)

538.6 3162

**Systematic Relations Existing between the Properties of Solid Materials**—C. Zwikker. (*Physica,'s Grav.*, vol. 14, pp. 35–47; January, 1948. In English.) Volume changes due to electrostriction, magnetostriction, or Barrett effect are discussed. Four independent relations are found between the following eight quantities: Hall effect, Seebeck effect, Nernst effect, Peltier effect, Ettinghausen effect, Leduc-Righi effect, electric resistivity, and thermal resistivity.

538.652 3163

**Longitudinal Magnetostriction of the Ferrites of Nickel and Magnesium**—R. Vautier. (*Compt. Rend. Acad. Sci.* (Paris), vol. 229, pp. 177–179; July 18, 1949.) The ferrites investigated all contained 50 per cent $Fe_2O_3$, with either NiO or MgO in proportions up to 50 per cent, the remainder being ZnO. Results are shown graphically.

546.212-16:621.317.335.3† 3164

**The Electrical Behaviour of Ice**—F. X. Eder. (*Ann. Phys.* (Lpz.), vol. 1, pp. 381–398; October 1, 1947.) See 1077 of 1948.

548.0:537.228.1 3165

**Piezoelectric Resonator of Ethylene Diamine Tartrate with Zero Temperature Coefficient of Frequency**—R. Bechmann. (*Nature* (London), vol. 164, pp. 190–191; July 30, 1949.) For the contour shear mode in square plates with two sides parallel to the $y$ axis and with the normal in the $xz$ plane, the temperature coefficient of frequency is zero when $\theta$, the angle between the normal and the $x$ axis, is 17° or 77°.

621.315.5/.6+669 3166

**The Development of New Materials**—F. E. Robinson. (*Marconi Rev.*, vol. 12, pp. 108–116; July and September, 1949.) Discussion of metals, alloys, and insulating materials developed during the war and only recently released to industry.

621.315.5/.6 3167

**Materials Section**—(*Electronics Buyers' Guide Issue*, vol. 22, pp. M1–M32; June, 1949.) Electrical, mechanical, and other significant characteristics of various materials used by the electronic industry are tabulated. Some of the tables are new; others are revised forms of tables such as those noted in 3131, 3133, 3142, 3146, 3150, and 3152 of 1948.

621.315.59:546.281.26 3168

**The Structure and Electrical Properties of Surfaces of Semiconductors: Part 1—Silicon Carbide**—T. K. Jones, R. A. Scott, and R. W. Sillars. (*Proc. Phys. Soc.*, vol. 62, pp. 333–343; June 1, 1949.)

621.315.59:621.3.011.2 3169

**The Temperature Dependence of the Resistance of Semiconductors**—J. H. Gisolf. (*Ann. Phys.* (Lpz.), vol. 1, pp. 3–26; January 3, 1947.)

621.318.22 3170

**Permanent Magnets and the Electrical Industry**—A. Edwards. (*Electrician*, vol. 142, pp. 1567–1571; May 20, 1949.) The magnetic energy of an Alcomax-III magnet is nearly 20 times that of the best magnet of equal size available 30 years ago. Corresponding advances in stability have also taken place. The properties and treatment of Alcomax and other materials are discussed, and the magnet shapes required for various applications are considered.

621.318.42:538.213 3171

**A Method, Based on the Gans Function, for Calculating the Effective Permeability of Premagnetized Choke Cores**—A. Weis. (*Funk. und Ton.*, vol. 3, pp. 438–448; August, 1949.) Calculation from the B/H curve gives values for the effective permeability which are

much too high. The method here described gives results in good agreement with measured values for air-gap chokes.

621.775.7 3172

**Methods of Iron Powder Manufacture and Their Influence on Powder Properties**—H. Bernstorff. (*Metal Treat.*, vol. 16, pp. 93–102; Summer, 1949.) A review of various German methods, including grinding, atomization, chemical reduction, and electrolysis. The influence of particle size and shape (shown in micrographs) on some of the physical properties of the finished product is discussed.

669.018:621.3.011.2 3173

**Pressure and Temperature Coefficients of the Electrical Resistance of Certain Alloys**—H. Ebert and J. Gielessen. (*Ann. Phys.* (Lpz.), vol. 1, pp. 229–240; May 22, 1947.) The results of measurements on a large number of alloys, including invar, thermostan, constantan, manganin, and series of Ag/Mn, Au/Mn, and Cu/Cr alloys, are presented graphically. The greatest pressure coefficient noted was $3.7\times10^{-6}$ per atmosphere for a Ag/Mn alloy with about 15 per cent (by weight) of Mn. The results indicate a relation between the two coefficients for a series of alloys, the pressure coefficient decreasing with increasing temperature coefficient.

533.5 3174

**Scientific Foundations of Vacuum Technique—[Book Review]**—S. Dushman. Publishers: J. Wiley and Sons, New York, 1949, 882 pp., $15.00. (*Rev. Sci. Instr.*, vol. 20, p. 453; June, 1949.) The book covers the applications and fundamentals of vacuum technology in the fields of physics, chemistry, and metallurgy. The completeness of the work recommends it as a reference book.

## MATHEMATICS

517.512:621.3.015.3 3175

**Contribution to the Study of Transient Phenomena by Means of Time Series**—M. Cuénod. (*Bull. Tech. Suisse Romande*, vol. 75, pp. 201–209; July 30, 1949.) The practical advantages of this method of calculation are considered. The method is outlined and applied to the determination of the response curve of a system and to integration, differentiation, the solution of linear differential equations and the determination of the conditions of stability of an automatic regulator. The relation between operational calculus and time-series methods is also indicated.

681.142 3176

**Electronic Techniques Applied to Analogue Methods of Computation**—G. D. McCann, C. H. Wilts, and B. N. Locanthi. (Proc. I.R.E., vol. 37, pp. 954–961; August, 1949.) The electronic devices and principles developed for the California Institute of Technology general-purpose, large-scale computer are described. This computer can be used for solving algebraic, ordinary differential, or partial differential equations, both linear and nonlinear.

681.142 3177

**Principles and Progress in the Construction of High-Speed Digital Computers**—A. D. Booth and K. H. V. Britten. (*Quart. Jour. Mech. Appl. Math.*, vol. 2, pp. 182–197; June, 1949.) Consideration of: (a) the basic principles underlying the mathematical design of high-speed digital computers, (b) the necessary components of such machines, (c) scale of notation, the form of the "memory," the action of the control, and other practical details, (d) the exact arithmetic functions of which these machines must be capable, (e) current computer projects in America, including Aiken's second relay computer at Harvard, the Bell relay machine, E.D.V.A.C., and the Princeton electronic computer, with reference to their state of completion in 1947.

681.142 3178

**A Digital Computer for Scientific Applications**—C. F. West and J. E. DeTurk. (Proc. I.R.E., vol. 37, p. 861; August, 1949.) Correction to 1107 of May.

681.142 3179

**A Magnetic Digital Storage System**—A. D. Booth. (*Electronic Eng.* (London), vol. 21, pp. 234–238; July, 1949.) The storage device consists of a cylindrical drum coated with magnetic material and rotating under a series of read/record heads arranged along a generator of the cylinder. Numbers are recorded in sequence as the drum rotates; to distinguish between them an extra track is added which contains a set of equally spaced positive "clock" pulses. The start of the clock pulse track is indicated by leaving a small gap free from pulses and using this as the zero position from which the position of any number can be obtained. Circuit and practical details are given.

681.142:621.392.5 3180

**Mercury Delay Line Memory Using a Pulse Rate of Several Megacycles [per Second].**—Auerbach, Eckert, Shaw, and Sheppard. (*See* 3082.)

517.564.4 3181

**Spherical Harmonics [Book Review]**—T. M. MacRobert. Publisher: Dover Publications, New York, 2nd edn 1948, 367 pp., $4.50. (Proc. I.R.E., vol. 37, p. 785; July, 1949.) Fourier series and Bessel, Legendre, and hypergeometric functions are covered as well as spherical harmonics. There is insufficient explanatory material for the engineer, but the treatment is thorough and useful for the applied mathematician.

517.63 3182

**An Introduction to the Laplace Transformation [Book Review]**—J. C. Jaeger. Publishers: Methuen and Co., London, 132 pp., 7s.6d. (*Wireless Eng.*, vol. 26, p. 276; August, 1949.) "The book contains the substance of a course of lectures delivered to engineers and physicists at the National Standards Laboratory, Sydney, in 1944 . . . [It] contains as little theory as possible; it is, in fact, largely a collection of worked examples illustrating the methods of solution of the various types of problem commonly arising in circuit theory."

## MEASUREMENTS AND TEST GEAR

531.764.5:621.396.615.18 3183

**A Compact Piezoelectric Chronometer**—J. E. Benson and E. M. Dash. (*Proc. I.R.E.* (Australia), vol. 9, pp+ 4–8; August, 1948. Discussion, p. 8.) See 1113 of May.

621.317+083.7 3184

**Radio Telemetering**—G. L. Hinckley. (*Electronic Eng.*, vol. 21. pp. 209–211, 223; June, 1949.) Factors influencing the choice of system.

621.317.3 3185

**Measurement of Impedance, Capacitance, Inductance and Frequency by the Method of Proportional Currents**—A. I. Fürstenberg. (*Compt. Rend. Acad. Sci.* (URSS), vol. 51, pp. 277–280; February 10, 1946. In English.) A method consisting essentially in equalizing the potential drop across constant nonreactive resistances in series with the impedances. A source of constant voltage and frequency is required.

621.317.3:621.385.38 3186

**The Deionization Time of Thyratrons: A New Method of Measurement**—H. de B. Knight. (*Proc. IEE* (London), part III, vol. 96, pp. 257–261; July, 1949.) A circuit providing two firing pulses at an adjustable interval is used to measure the time required to reestablish grid control. Typical deionization times and grid-current decay curves are given for various tube structures and fillings. See also 2553 of October (Birnbaum.)

621.317.312:621.314.632 3187

**Use of Copper-Oxide Rectifiers for Measuring the Smallest Alternating Voltages**—H. Ifland. (*Funk. und Ton.*, vol. 3, pp. 449–454; August, 1949.) Temperature effects in the bridge type of rectifier normally used with moving-coil instruments for ac measurements can be partially compensated by connecting a resistor of suitable value in series with the instrument. Circuit details are given of a multirange meter with full-scale readings from 0.1V to 300V.

621.317.33:621.396.611.33 3188

**Simplified Measurement of L and k**—V. A. Sheridan. (*Electronics*, vol. 22, pp. 146, 154; August, 1949.) The coupling coefficient $k$ is determined from the change in effective inductance of one winding of a pair of inductively coupled circuits when the other winding is first open-circuited and then short-circuited. Accuracies within 1 per cent are obtained with the bridge described, which is fed through a double-tuned transformer from a 23-kc oscillator and is suitable for measurements on most rf transformers.

621.317.333.4:621.315.23 3189

**Cable Fault Finder**—F. E. Planer. (*Elec. Rev.* (London), vol. 145, pp. 57–58; July 8, 1949.) Short description of portable inductive test equipment. A conductor carrying 1 mA ac can be detected at a distance of 45 ft. A direct indication of cable depth is tiven.

621.317.335.3† 3190

**Construction of Apparatus for Very Accurate Measurement of the Dielectric Constant of Liquids**—Mouradoff-Fouquet. (*Ann. Phys.* (Paris), vol. 4, pp. 310–367; May and June, 1949.) A double-beat method using oscillations of medium wavelength, with capacitors of extremely accurate mechanical construction for containing the liquids and with arrangements for maintaining the temperature at any desired value, enabled the dielectric constant of various organic liquids to be measured to about 1 part in 20,000.

621.317.335.3†:546.212-16 3191

**The Electrical Behaviour of Ice**—F. X. Eder. (*Ann. Phys.* (Lpz.), vol. 1, pp. 381 398; October 1, 1947.) *See* 1077 of 1948.

621.317.336:621.317.372 3192

**The Development of Q-Meter Methods of Impedance Measurement**—A. J. Biggs and J. E. Houldin. (*Proc. IEE* (London), part III, vol. 96, pp. 295–302; July, 1949. Discussion, pp. 303–305.) Three usual definitions of $Q$ are shown to be equivalent for a system at simple resonance. Circuit magnification factor is discussed in relation to $Q$, and circuits for measuring $Q$ are critically examined. A new high-impedance injection meter is described and illustrated, with details of precautions necessary for hf measurements.

621.317.336.1:621.392.52 3193

**Measurements on Intermediate-Frequency Transformers**—E. Stern. (*Jour. Brit. I.R.E.* vol. 9, pp. 157–166; April, 1949.) A method is described for testing double-tuned transformers with a $Q$-meter or any other rf resistance meter. The resonance transfer impedance of two coupled circuits is expressed in a form independent of the nature of the coupling reactance. Charts are provided from which the transfer impedance of a transformer can be determined from three $Q$-meter readings. These readings can also be used to determine the frequency response curve from published generalized response curves if the tuning capacitances are known. Simple formulas for the bandwidth at —60 db of composite systems containing single- and double-tuned circuits of different dynamic resistances and coupling are also

given. Reprinted from *Proc. I.R.E.* (Australia), vol. 9, pp. 4–11; January, 1948.

621.317.361:621.385.832 3194

**A Cathode-Ray Tube Frequency Comparator for 1 kc/s Sub-Standard Tones**—J. F. M. Laver. (*P. O. Elec. Eng. Jour.*, vol. 42, pp. 61–64; July, 1949.) The nominal 1-kc tone transmitted by land line from a distant source is applied to the X plates of a cr tube which is modulated in brilliancy by means of a 100-kc frequency standard. The movement of the resultant dot pattern is used to compare the two frequencies rapidly. The method is more reliable than a heterodyne method in the presence of noise or interference voltages. Applications, sources of error, and accuracy are discussed.

621.317.382.029.64 3195

**Broad-Band Power-Measuring Methods at Microwave Frequencies**—L. E. Norton. (Proc. I.R.E., vol. 37, pp. 759–766; July, 1949.) The first method uses the forces due to the em fields in a transmission system to cause displacements of a diaphragm which are proportional to the square of the actuating field. In the second method, thin films are inserted in a transmission system so as to cause only small discontinuities. The small fraction of the power dissipated in the film raises its temperature and changes its resistance, which is measured. In both methods the output of the indicator system is proportional to the power within ±1 db between 1,000 and 10,000 Mc.

621.317.66 3196

**Measurement of Microwave-Transmission Efficiency**—A. L. Cullen. (*Wireless Eng.*, vol. 26, pp. 255–257; August, 1949.) The transmission efficiency of any transmission device is defined as the ratio (power out)/(power in) when the device is inserted in an otherwise matched transmission system. If the reflection coefficient for waves incident on the normal output end of the device, with the input end closed by a movable short-circuiting plunger, is plotted in the complex plane for several positions of the plunger, the points obtained will lie on a circle of radius equal to the transmission efficiency.

621.317.66:621.39 3197

**Measurement of Telecommunications Efficiency**—(*Proc. IEE* (London), part III, vol. 96, pp. 277–278; July, 1949.) Report of an IEE discussion meeting. No satisfactory objective test of quality is as yet available; existing subjective tests of loudness and intelligibility are compared.

621.317.7.029.63 3198

**Measurement Apparatus for Decimetre Waves**—H. H. Meinke. (*Fernmeldetech. Z.*, vol. 2, pp. 197–200; July, 1949.) Illustrations and short general description of (a) equipment comprising supply unit, transmitter, circular transmission line for impedance measurement (see 3203 below), receiver and cro indicator, (b) capacitive voltage divider, (c) diode, (d) transmission line of length variable as in a trombone, (e) reactive transmission line of characteristic impedance 70Ω, and (f) bolometer for power measuremetn in the range $10^{-2}$–$10^{-6}$ W.

621.317.715 3199

**The Alternating Current Galvanometer**—J. M. W. Milatz, P. M. Endt, C. T. J. Alkemade, and J. T. Olink. (*Physica, 's Grav.*, vol. 14, pp. 260–268; May, 1948. In English.) Theory is given which takes into account the induction current caused by the vibration of the moving system. The galvanometer can be made aperiodic and "field independent" with a combination of ac and dc magnetic fields, or with another damping device replacing the dc field. Measurements confirming the theory are described.

621.317.715 3200

**On the Limit of Sensitivity of Galvanometers**—M. Surdin. (*Jour. Phys. Radium*, vol. 10, pp. 253–254; July and September, 1949.) A formula is established giving the spectral intensity of the brownian couple which acts on a mechanical or an electrical system satisfying a linear differential equation of the second order and having a single degree of freedom. It is deduced that the sensitivity limit of a galvanometer remains the same whether the measurement circuit is open or closed.

621.317.715 3201

**Valve Galvanometer with Ordinary Valves**—J. Kreuzer. (*Z. Phys.*, vol. 125, pp. 707–714; March 15, 1949.) Special electrometer tubes are normally used in apparatus for the measurement of very small currents such as that given by a photocell, but with ordinary tubes currents as low as $10^{-13}$A can be measured and a limit of $10^{-14}$A may be reached with selected tubes. Details of practical equipment using a KF4 pentode, which has a well-insulated grid, are given.

621.317.73:549.514.51 3202

**The Measurement of the Series-Resonant Resistance of a Quartz Crystal**—L. A. Rosenthal and T. A. Peterson, Jr. (*Rev. Sci. Instr.*, vol. 20, pp. 426–429; June, 1949.) Two methods of measuring the equivalent resistance of commercial plated or pressure-mounted quartz crystals in the frequency range 80 kc to 100 Mc are discussed, namely (a) the substitution method, in which a resistor replaces the crystal unit, the amplitude of oscillation being maintained constant, and (b) the calculation method in which the quantities actually measured are the voltage drop across the crystal and the current through the unit. Three instruments are described in which combinations of these methods are used. Typical results are discussed.

621.317.73.029.63 3203

**A Measurement Line with Visual Indicator**—H. H. Meinke. (*Fernmeldetech. Z.*, vol. 2, pp. 233–241; August, 1949.) A device for measuring impedance in the dm-λ range. It consists essentially of a transmission line forming nearly a complete circle, with a motor driven rotary radial arm making contact with both the inner and outer conductor. The actual instrument is accurately machined and the end of the rotary arm makes contact with the inner conductor through a slot on the inner face of the line. A generator is connected to one end of the line, which is terminated by the impedance to be measured. Capacitive couplings to the two contacts on the rotary arm enable the shape of the voltage wave along the line to be displayed on a cro. The voltage picked up by the contacts is amplified, heterodyned to give a difference frequency of 3 Mc and, after further amplification and rectification, applied to the cro. Typical oscillograms are given, the method of calibration is described and also applications to phase measurement and to various measurements on receivers and transmitters. The apparatus is one unit of the equipment noted in 3198 above.

621.317.772 3204

**Resistive Phase Shifters**—J. E. Bryden. (*Electronic Eng.* (London), vol. 21, pp. 322–326; September, 1949.) Description of a phase-shifter for which power is supplied from an electronic single-phase/6-phase conversion unit. Advantages, possible errors and their elimination, and applications are discussed.

621.317.78.029.64 3205

**Broadband Bolometric Measurement of Microwave Power**—H. J. Carlin. (*Radio and Telev. News, Radio Electronic Eng. Supplement*, vol. 13, pp. 16–19; July, 1949.) Theory and description of broad band units for the ranges 20 to 1,000 Mc, 1,000 to 4,000 Mc, and 4,000 to 10,000 Mc. One type, using Wollaston wire, is suitable for low-power measurements from 25μW to 1 mW, with extension to 10 mW if an attenuator is used. Another type uses metal film for powers from 1 mW to 50 mW, with extension to 5 W. Typical curves for voltage swr are given.

621.319.4.001.4 3206

**Direct Voltage Performance Test for Capacitor Paper**—H. A. Sauer and D. A. McLean. (Proc. I.R.E., vol. 37, pp. 927–931; August, 1949.) Discussion of a testing procedure requiring about a day for preparation of samples and about another day for the actual life test. See also 965 of 1948 (McLean).

621.395.623.7.089.6 3207

**Physical Measurements of Loudspeaker Performance**—P. S. Veneklasen. (*Jour. Soc. Mot. Pic. Eng.*, vol. 52, pp. 641–656; June, 1949.) Facilities for outdoor calibration of loudspeakers and microphones at the Altec Lansing Corporation, California, are described. Techniques are illustrated by measurements of frequency response, angular distribution, and distortion for a typical loudspeaker. Methods for uniform presentation of performance data and specifications are also suggested. Smooth and clean reproduction over a limited range of frequencies should be achieved before wide-range reproduction will be worth while.

621.396.615 3208

**Beat-Frequency Oscillator for the Carrier-Frequency Range**—H. Boucke and H. Lennartz. (*Fernmeldetech. Z.*, vol. 2, pp. 245–248; August, 1949.) Details of a 1944 model, Type SR200R, which is not limited to carrier frequencies, its frequency range being from 50 cps to 200 kc. Curves show the output voltages into 150-Ω and 600-Ω loads for the two ranges 50 to 15,000 cps and 10 to 200 kcs. Distortion curves are also given.

## OTHER APPLICATIONS OF RADIO AND ELECTRONICS

538.63 3209

**Focusing Properties and Separating Power of a Magnetic Field bounded by Parallel Planes.**—R. Vauthier. (*Compt. Rend. Acad. Sci.* (Paris), vol. 229, pp. 181–183; July 18, 1949.) Such a magnetic field can be used in the construction of a mass spectrometer, the separating power being nearly equal to that of a magnetic sector.

539.16.08 3210

**An Automatic Timer for Radioactivity Measurements**—B. D. Corbett and A. J. Honour. (*Electronic Eng.* (London), vol. 21, pp. 341–345; September, 1949.) Circuit and construction details for a timer to be used in conjunction with a commercial electronic scaler developed by the Atomic Energy Research Establishment. Hundreds of counts, minutes, and seconds are displayed on three easily reset dial-type registers. The duration of operation may be present in the range 1 second to 200 minutes, or alternatively the number of counts may be preset in the range 100 to 20,000. Units and tens of counts are displayed by means of neon lamps.

539.16.08 3211

**Geiger Counter Tubes**—H. Friedman. (Proc. I.R.E., vol. 37, pp. 791–808; July, 1949.) Discussion of various types and their special characteristics and applications. 68 references are given.

539.16.08 3212

**Geiger-Müller Counters with External Cathode**—D. Blanc and M. Schérer. (*Compt. Rend. Acad. Sci.* (Paris), vol. 228, pp. 2018–2020; June 22, 1949.) The performance of this type of counter is improved by connecting the graphite coatings on the ends of the tube to the axial wire, thus eliminating end effects. The curve for counting rate as a function of the length of the central graphite cathode, for a given voltage, is then a straight line passing through the origin. The plateau is lengthened by 50 per cent or more compared with normal counters. Argon-alcohol and argon-methane

counters were investigated, of lengths from 20 cm to 1 m and diameters from 0.9 cm to 3.5 cm. Improved results were obtained in all cases. Counters which were defective or had poor plateaux could be reconditioned by the graphite-coating technique.

539.16.08 3213
**Point Counters and Counter Tubes for Surface Investigations in Metallography**—J. Kramer. (*Z. Phys.*, vol. 125, pp. 739–756; March 15, 1949.) Many examples are given showing the wide scope of counter methods in such research.

539.16.08 3214
**Experiments in the Possibility of Increasing the Efficiency of Gamma-Counters**—H. Slätis. (*Rev. Sci. Instr.*, vol. 20, pp. 353–354; May, 1949.) Abridged version of 2873 of November.

549.211:539.16.08 3215
**Removal of Space-Charge in Diamond-Crystal Counters.**—A. G. Chynoweth. (*Phys. Rev.*, vol. 76, p. 310; July 15, 1949.) The use of radiation from a Nernst filament, of wavelength 1–10 mμ, is quite satisfactory for removing the space charge which causes decay of counting rate.

620.179.16:534.23 3216
**On Sound Transmission through Metal Plates in Liquids for Oblique Incidence of Plane Waves**—Götz. (See 2998).

621.396.615:621.317.083.7 3217
**Transistor Oscillator for Telemetering**—Lehan. (See 3095).

621.38.001.8 3218
**Electronic Equipment for the Production Engineer** (*Jour. Brit. I.R.E.*, vol. 9, pp. 222–237; June, 1949.) Report of a discussion. Examples demonstrate the wide range of operations that, by the development of new or the adaptation of existing instruments, can be controlled or carried out, rapidly and reliably, by electronic means. Specialization is essential in so wide a field. Selected electronic control units are illustrated and described.

621.38.001.8 3219
**The Fourth Manchester Electronics Exhibition**—(*Electronic Eng.* (London), vol. 21, pp. 336–337; September, 1949.) Brief descriptions of various exhibits, including evaporating and sputtering plant, a servodyne, a cro, a tube test panel, an electron microscope, an inductance bridge, a microsecond chronometer, etc.

621.38.001.8 3220
**Electronic Equipment at the B. I. F.**—(*Electronic Eng.* (London), vol. 21, pp. 224–227; June, 1949.) Brief descriptions of various exhibits.

621.38.001.8:621 3221
**Electronics in Heavy Engineering**—W. Wilson. (*Jour. Brit. I.R.E.*, vol. 9, pp. 278–305; August, 1949.) A comprehensive review including discussion of high-power rectifiers, industrial hf generators, amplification and control apparatus, servomechanisms, motor control, and applications of the cro.

621.384.6 3222
**Beam Extraction for the Electron Centrifuge**—K. Gund and H. Reich. (*Z. Phys.*, vol. 126, pp. 383–398; May 27, 1949.) Discussion of the problem for the betatron, synchrotron, and FM cyclotron, and description of a method permitting 70 per cent of the electrons to be extracted in the form of a narrow beam.

621.384.611.2† 3223
**Hospital Synchrotron**—J. H. Martin. (*Elec. Rev.* (London), vol. 145, pp. 277–279; August 12, 1949.) The first of two 30-MeV synchrotrons designed for the Medical Research Council has recently been installed at the Royal Cancer Hospital, London. Photographs and a few technical details of the equipment are given. The total weight is about 3 tons.

621.384.611.2† 3224
**The Synchrotron Accelerator—its Potentialities as a Generator of X-Rays and Electrons of 10-50 MeV Energies for Medical Use**—D. W. Fry. (*Brit. Jour. Radiol.*, vol. 22, pp. 462–472; August, 1949.) The principle of the electron synchrotron is considered and the main characteristics of a $\beta$-synchrotron are illustrated by reference to the operation of a 14-MeV and a 30-MeV electron synchrotron. With the 30-MeV machine an output of 13 r per minute at 1 m has been obtained. The X-ray characteristics are described and the possibility of extracting the electron beam for clinical use is discussed. The main factor controlling the design of both betatrons and synchrotrons at present is the injection process. If the efficiency of injection could be increased, a major improvement would result in synchrotrons and betatrons designed for clinical work.

621.384.62† 3225
**The Microwave Linear Electron Accelerator**—G. R. Newbery. (*Brit. Jour. Radiol.*, vol. 22, pp. 473–496; August, 1949.) Various types are briefly described and a detailed account is given of traveling-wave, standing-wave, and multicavity accelerators. The theoretical and practical limitations of the performance of each type at 3,000 Mc are discussed. The design of linear accelerators, suitable for medical use at this frequency is considered; tentative designs for 5-MeV and 10-MeV machines are given.

621.385.832:[535+77 3226
**Cathode-Ray-Tube Applications in Photography and Optics**—C. Berkley and R. Feldt. (*Jour. Soc. Mot. Pic. Eng.*, vol. 53, pp. 64–85; July, 1949.) Reprint of article noted in 2596 of October.

621.397.3:539.211 3227
**The Electron Scanner—an Image Method Using Secondary Electrons**—J. te Gude. (*Funk. und Ton.*, vol. 3, pp. 373–383; July, 1949.) Principles and construction of apparatus using an electron beam for scanning a surface to be examined, and obtaining an image by means of the secondary electrons emitted from the surface. Applications to the investigation of surface films, such as those of $Cu_2O$ rectifiers, and to corrosion research are mentioned. See also 4111 of 1939 (Knoll and Theile) and 2509 and 3593 of 1941 (Knoll).

620.179.16:534.321.9 3228
**Ultrasonics [Book Review]**—Carlin. (*See* 3032.)

## PROPAGATION OF WAVES

538.56:535.421 3229
**On the Diffraction of a Plane Wave by a Semi-Infinite Conducting Sheet**—C. W. Horton. (*Phys. Rev.*, vol. 75, p. 1263; April 15, 1949.) At radar frequencies the detecting unit is much smaller than the region in which Sommerfeld's diffraction formulas are invalid. Approximate expressions are here given for the electric vector of the diffraction field within the excluded regions, when the electric vector is parallel to the edge of the screen, with similar expressions for the magnetic vector when this is parallel to the diffracting edge. The symbols used are those defined by Baker and Copson (2907 of 1940).

538.566+621.396.11 3230
**On the Propagation of Radio Waves around the Earth**—H. Bremmer. (*Physica's Grav.*, vol. 14, pp. 301–318; June, 1948. In English.) A general discussion of existing theories and the extensions required by the discovery of new phenomena-like superrefraction. For a fuller account see 3242 below.

538.566 3231
**Reflection of Electromagnetic Waves at an Inhomogeneous Layer**—W. Kofink. (*Ann. Phys.* (Lpz.), vol. 1, pp. 119–132; January 3, 1947.) Mathematical study of several methods of calculating the reflecting power of a layer in which the dielectric constant varies with depth in the layer. The essentials of the following methods are presented: (a) the functional method; (b) the method of van Cittert; (c) the method of Gans (WKB method); (d) a differentiation method. (c) and (d) are only applicable to layers of finite thickness.

538.566.3 3232
**On the Theory of the Double Refraction of Electromagnetic Waves in an Ionized Gas under the influence of a Constant Magnetic Field (Ionosphere)**—H. Lassen. (*Ann. Phys.* (Lpz.), vol. 1, pp. 415–428; October 1, 1947.) The complex refractive index and the waveform are calculated in a simple manner. A relation is established between previous calculations by Försterling and the author and the formulas of Appleton, Goldstein, and Hartree.

621.396.11 3233
**Ground-Wave Propagation across a Land/Sea Boundary**—G. Millington and N. Elson. (*Nature* (London), vol. 164, pp. 114–116; July, 16, 1949.) An increase of field strength on crossing the coastline was observed by Millington for 3.13-Mc radiation along a path passing for about 100 km overland and then across the English Channel. The field strengths along this path are shown graphically; the results confirm the theory previously given (1758 of July). See also 2307 of September.

Measurements of the field strength of 1.122-Mc transmissions from Crowborough were made by Elson in an aircraft flying at a height of 1,000 ft across East Anglia and then over the North Sea. At the frequency used, both land and sea are essentially conducting. A major recovery of field strength was noted about 25 miles beyond the coastline. The results confirm Millington's theory. A small recovery effect was noted on crossing the Thames estuary.

621.396.11:551.510.535 3234
**Correlation of Sporadic E Region Ionization over Short Distances and Comparison with Magnetic Disturbances**—Gerard. (*See* 3135).

621.396.11:551.510.535:518.3 3235
**Nomograms for Ionosphere Control Points**—J. C. W. Scott. (Proc. I.R.E., vol. 37, pp. 821–824; July, 1949.) An abac for determining the latitudes of the ionospheric control points, given the length of a radio circuit and the latitudes of its terminals. This simplifies the use of world m.u.f. charts.

621.396.11:621.396.812.3 3236
**On the Fading of Short Waves**—W. Menzel. (*Fernmeldetech. Z.*, vol. 2, pp. 243–244; August, 1949.) Discussion with special reference to Ratcliffe's theory (193 of February).

621.396.11:621.396.93 3237
**Scattering of Radio Waves by Metal Wires and Sheets**—F. Horner. (*Proc. IEE* (London), part III, vol. 96, pp. 333–340; July, 1949. Discussion, pp. 340–345.) Formulas for the scattered fields are derived, using transmission-line theory for wires and diffraction theory for sheets. Measurements of the scattered fields have been made at a frequency of 600 Mc, using a direction finder as the indicating instrument; the results are in substantial agreement with theory. For wires of the order of 1 mm in diameter and more than 5λ long, resonance effects at 600 Mc are small. Such effects are negligible in sheets whose dimension normal to the electric vector is greater than λ.

621.396.81: 3238
**Reception at over 16000 km from the Transmitter**—R. G. Sacasa. (*Rev. Telecommun.* (Madrid), vol. 3, pp. 11–15; June, 1948.)

Graphs show the variations during March, 1948, of receiver output power at Madrid for Australian broadcasting stations on wavelengths of 16.82, 19.74, and 25.49 m. Measurements were made daily at 0730 GMT at peak modulation. Comparison with measurements on the 32-m signals from the Arganda station, Madrid, only 17 km from the receiving station, revealed definite correlation with the variations of the Australian 25.49-m signals.

621.396.812 3239

**Anomalous Radar Propagation over Land in the Period November 29 to December 1, 1948**—R. F. Jones. (*Met. Mag.*, vol. 78, pp. 233–234; August, 1949.) The abnormal ranges obtained during this period at a radar station near Dunstable for $\lambda = 10$ cm were associated with a rapid lapse of water-vapor content above fog. Radiosonde data do not indicate precisely the boundaries of the dry layers, because of the rate of ascent of the balloon and the time-lag in the humidity element.

621.396.812.029.62 3240

**U.H.F. Propagation Characteristics**—E. W. Allen, Jr. (*Electronics*, vol. 22, pp. 69–89; August, 1949.) From the results of 13 vhf surveys made by the National Bureau of Standards, correction factors have been determined for expected median field-strengths; these corrections are applicable to the FCC groundwave signal/range charts for frequencies from 63 to 195 Mc.

621.396.812.029.64 3241

**Microwave Phase Front Measurements for Overwater Paths of 12 and 32 Miles**—A. W. Straiton. (PROC. I.R.E., vol. 37, pp. 808–813; July, 1949.) Continuous curves of phase and signal strength at a wavelength of 3.2 cm are shown for a range of transmitter and receiver heights from 10 ft to 55 ft above mean sea level The results for the two paths are compared, and deviations from those commonly expected for oversea propagation are noted.

538.566+621.396.11 3242

**Terrestrial Radio Waves [Book Review]**—H. Bremmer. Publishers: Cleaver-Hume Press, London, 344 pp., 36 s. (*Wireless Eng.*, vol. 26, pp. 275–276; August, 1949.) The book is based on researches of the author originating in classic papers written in collaboration with van der Pol. It will appeal most to the mathematical physicist who can follow the general line of the analysis, but there are sections of direct use to the engineer. ". . . this book will be a mine of information to the few to whom will fall the task of tackling the outstanding problems of propagation theory."

## RECEPTION

621.396.62.029.58 3243

**The Orchestra in Your Home. The TR138.**—R. Geffre. (*Toute la Radio*, vol. 16, pp. 243–248; September, 1949.) Complete circuit details of a high-fidelity sw receiver with ample sensitivity for good reproduction in France of transmissions from the U.S.A. Special features of the various stages are discussed.

621.396.621 3244

**A High-Performance Dual-Conversion Superhet**—R. C. Cheek. (*CQ*, vol. 5, pp. 16–23, 77; July, 1949.) Complete details of a receiver which operates directly from the antenna on 3.5 and 7 Mc, but which is preceded by an hf converter when operating on 14, 21, 27, or 28 Mc. Alignment procedure is described.

621.396.621 3245

**Philips Model 681A**—(*Wireless World*, vol. 55, pp. 289–290; August, 1949.) Test report. Normal tuning is provided in a superheterodyne circuit for wavelength ranges 11.1–34.2 m, 34.2–110.5 m, 192–560 m, and 900–2,000 m. There are also 8 selected sw broadcast bands of width about 0.5 Mc centered at wavelengths 11, 13, 16, 19, 25, 31, 41, and 49 m, for which a double superheterodyne principle is used in the bandspread circuits, so that the local oscillator on each band works at a fixed frequency and is thus easier to stabilize.

621.396.621:621.396.619.13 3246

**The Demodulation of a Frequency-Modulated Carrier and Random Noise by a Discriminator**—N. M. Blachman. (PROC. I.R.E., vol. 37, p. 895; August, 1949.) Summary only. See also 1772 of July.

621.396.621:621.396.65.029.58 3247

**The Receiving System at Cooling [Kent] Radio Station**—C. F. Booth. (*P. O. Elec. Eng. Jour.*, vol. 42, pp. 84–89; July, 1949.) The factors limiting the performance of long-distance R/T links operating in the frequency range 3 to 30 Mc are outlined with particular reference to the downcoming angle at the receiver. The receiver system described uses a highly directive steerable antenna arranged to feed four parallel receiver branches, one of which gives an energy/downcoming-angle diagram on a cr tube from which the other three are manually set to three different optimum angles. Performance is compared with that for a receiver having a single antenna of possible future developments of directive receiving systems are considered. The system is similar to the M.U.S.A. system noted in 3016 of 1940 (Polkinghorn).

621.396.823 3248

**Car-Ignition Interference**—W. Nethercot. (*Wireless Eng.*, vol. 26, pp. 251–255; August, 1949.) The wide-band continuous radiation from the ignition circuit is due to traveling waves set up in the hv cables when the distributor and sparking-plug gaps break down. The current through the sparking-plug gap consists of a series of very steep-fronted steps, the intervals between which are determined by the time the waves take to travel twice the length of the hv cables. The envelope of these current steps is oscillatory and its frequency lies between 30 and 50 Mc. Resistors at the sparking-plug and distributor terminals should give suppression over the whole frequency band.

621.396.828 3249

**Goniometer Arrangement for the Suppression of Interfering Transmissions by means of Angle Measurement with Beam-Aerial Systems**—H. Fricke. (*Fernmeldetech. Z.*, vol. 2, pp. 249–253; August, 1949.) Two antennas, whose beams are directed towards the wanted station, are connected to the two stator coils of the goniometer, a phase-shifter being interposed between antenna and coil in one case. The receiver is connected to the goniometer search coil. With suitable adjustment of the phase-shifter and of the position of the search coil, signals from an unwanted transmitter operating on the same wavelength as that of the wanted station can be completely eliminated.

## STATIONS AND COMMUNICATION SYSTEMS

621.39:061.053 3250

**The Third Session of the Administrative Council of the International Telecommunications Union (I.T.U.) [Geneva, 1948]**—G. Gneme. (*Poste e Telecomun.*, vol. 16, Supplement, pp. 26–34; November, 1948.)

621.395.44:621.396.619.2 3251

**A 48-Channel Carrier Telephone System: Part 2—Mechanical Construction**—G. H. Bast, D. Goedhart, and J. F. Schouten. (*Philips Rech. Rev.*, vol. 10, pp. 353–358; June, 1949.) Part 1: 236 of 1948.

621.396 3252

**Modern Tendencies in Commercial Long-Distance Radio Communications**—A. Niutta. (*Poste e Telecomun.*, vol. 16, pp. 241–251; June and July, 1948.) A review covering single-sideband transmission, frequency-shift keying, and multiplex teleprinter systems.

621.396:061.3 3253

**The Fifth Meeting of the C.C.I.R. [Stockholm, July 1948]**—T. Gorio. (*Poste e Telecomun.*, vol. 16, pp. 493–502; December, 1948.)

621.396.1 3254

**The European Broadcasting Conference at Copenhagen [1948]**—G. Gneme. (*Poste e Telecomun.*, vol. 16, Supplement, pp. 1–16; November, 1948.) Detailed report, with special consideration of the position of Italy.

621.396.1 3255

**The Copenhagen Maritime Regional Radiocommunication Conference [1948]**—G. Gneme. (*Poste e Telecomun.*, vol. 16, Supplement, pp. 17–25; November, 1948.) Full details on allocations to coastal stations and to ships.

621.396.61.029.54:621.396.712 3256

**B.B.C. Transmitting Station at Postwick Grange**—(*Engineer* (London), vol. 188, p. 77; July 15, 1949.) Further details of the new station near Norwich. The antenna system consists of two 126-ft tubular masts spaced $\lambda/4$ apart. The easterly mast is energized; the resulting directional system brings Yarmouth within the service area. See also 2942 of November.

621.396.619.11/.13 3257

**F.M. vs A.M.**—D. J. Braak. (*Electronics*, vol. 22, pp. 218, 220; August, 1949.) Comment on some of the statements made in the paper abstracted in 1504 of June (Toth.)

621.396.619.16:621.396.41 3258

**A Time-Division Multiplexing System**—W. P. Boothroyd and E. M. Creamer, Jr. (*Elec. Eng.*, vol. 68, pp. 583–588; July, 1949.) A system using pulse-amplitude modulation with a filtering arrangement for minimizing the required transmission bandwidth.

621.396.65.029.58:621.396.621 3259

**The Receiving System at Cooling [Kent] Radio Station**—Booth. (*See* 3247.)

621.396.931 3260

**Portable F.M. Equipment**—H. V. Carlson. (*FM-TV*, vol. 9, pp. 14–16; July, 1949.) Description of a unit weighing less than 10 lb, which operates at a fixed frequency in the ranges 25 to 50 Mc or 152 to 165 Mc and provides 2-way communication over distances of several miles under noisy conditions.

621.396.931 3261

**A 28-Mc/s Installation for the Car.**—G. P. McGinnis. (*QST*, vol. 33, pp 11–16; August, 1949.) Construction and installation details for amateur equipment which does no damage to the car and only requires an input of 17 W.

621.396.932 3262

**Automatic Station Call Selector**—W. W. McGoffin and R. H. Schulz. (*Electronics*, vol. 22, pp. 75–77; August, 1949.) An instrument which sounds an alarm at a radio station when its own call letters are received at any sending speed from 6 to 34 words per minute.

## SUBSIDIARY APPARATUS

621.314.58 3263

**Thyratron Replaces Vibrator**—(*Electronics*, vol. 22, pp. 140, 144; August, 1949.) Description, with circuit diagram, of a simple dc/ac converter which operates from a 6-V battery and has no moving parts.

621.316.722:621.396.682 3264

**Pre-Calculation of Magnetic Voltage Stabilizers**—W. Taeger. (*Funk. und Ton.*, vol. 3, pp. 429–437; August, 1949.) Design procedure, with numerical calculations for an output power of 75 W at 220V. With mains voltage

variations from 160V to 260V, the stabilized voltage only varied from 215V to 224V, in good agreement with theory.

621.316.726 3265
**Frequency Correction of Electric Signalling Power Supplies**—E. Friedlander and R. A. Duncan. (*GEC Jour.*, vol. 16, pp. 130–137; July, 1949.) Detailed description of the equipment noted in 2054 of August, with particular reference to special features such as the frequency relay and protective devices for tripping in case of hunting or failure to correct the frequency. The frequency relay is based on the principle of phase change in a resonant circuit; its construction and operation are clearly explained.

621.396.68:539.16.08 3266
**Miniature Counter-Tube Power Supply**—D. L. Collins. (*Electronics*, vol. 22, pp. 170–173; August, 1949.) The high voltage is obtained across a miniature transformer in a blocking-oscillator circuit using a 1V5 tube. The oscillator pulses are rectified by a low-power hv half-wave VX-21 rectifier. Regulation is obtained by means of a 900-V corona voltage regulator.

621.396.682 3267
**30-kV D.C. Regulated Power Supply**—W. Spellman. (*Radio and Telev. News, Radio-Electronic Eng. Supplement*, vol. 12, pp. 16–17, May 30, 1949.) Circuit diagram, without component values, of a supply unit giving an output from 25 to 30 kV; regulation is within 1 per cent under load variations from zero to 1 mA and line-voltage variations from 95 to 125V.

621.396.682:621.316.722.1 3268
**An Electromechanically Stabilised Mains Supply Unit**—A. E. Maine. (*Electronic Eng.* (London), vol. 21, pp. 319–321; September, 1949.) A neon-tube bridge and a voltage-sensing circuit with gas triodes are used to control a bidirectional motor which adjusts the tappings on a variable-ratio transformer, thus correcting any deviation from the required voltage. The output voltage is regulated within 1 per cent, for loads up to 1.5 kVA and for voltage deviations of −15 per cent to +5 per cent.

621.314.632 3269
**Metal Rectifiers [Book Review]**—H. K. Henisch. Publishers: Oxford University Press, 168 pp., 15 s. (*Electronic Eng.* (London), vol. 21, p. 229; June, 1949.) The book will be useful both to students as an introduction to electronic properties of solids and to practical users of dry rectifiers who require a critical but compact account of the subject. The book contains no difficult mathematics.

## TELEVISION AND PHOTOTELEGRAPHY

621.397.331.2 3270
**Slow-Electron Television Cameras**—J. J. M. Moral. (*Rev. Telecomun.* (Madrid), vol. 3, pp. 38–52; June, 1948.) Operating principles and characteristics of the iconoscope, orthicon, and isoscope tubes.

621.397.331.2 3271
**Distortion of Scanning Waveforms**—G. G. Gouriet. (*Electronic Eng.* (London), vol. 21, pp. 327–331; September, 1949.) Requirements for a linear scan are discussed. The distortion due to insufficient bass response and means of correcting this distortion are also considered.

621.397.5 3272
**Televising Moving Images**—R. W. Hallows. (*Wireless World*, vol. 55, pp. 291–293; August, 1949.) Calculations of balanced definition for moving images should not be based entirely on data for still images, since moving images introduce many new problems. The greatest immediate need is for developing methods of producing wide-band transmitting and receiving apparatus at reasonable cost.

621.397.5:535.88 3273
**Three-Dimensional Picture Screens for Television and the Cinema**—E. G. Beard. (Proc. I.R.E. (Australia), vol. 9, pp. 4–16; June, 1948). Previous attempts to produce 3-dimensional pictures on a flat screen are discussed and a practical screen is described. Manufacturing tolerances and the modifications necessary to adapt this screen for use in cinema theaters are considered. An experimental screen gave promising results.

621.397.5:535.88 3274
**A Projection System for Domestic Television Receivers**—(*Electronic Eng.* (London), vol. 21, pp. 314–318; September, 1949.) Discussion of a Mullard folded-Schmidt system giving adequate resolution for picture sizes up to 15 in. by 12 in., which can be used in conjunction with most existing receiver chasses. See also 2387 of 1948 (Rinia et al.)

621.397.5:535.88 3275
**Home Projection Television: Parts 1–3**—H. Rinia, J. de Gier, P. M. van Alphen, G. J. Siezen, J. Haantjes, and F. Kerkhof. (Proc. I.R.E. (Australia), vol. 9, pp. 9–18; August, 1948.) Abridged version of 2387 of 1948.

621.397.5:617 3276
**Television as an Aid to Teaching Operative Surgery**—(*Electronic Eng.* (London), vol. 21, pp. 212–213; June, 1949.) Short description of specially designed equipment installed in Guy's Hospital, London, which enables the progress of operations to be followed by many observers without crowding the operating theater. At present four viewing sets with 15-in. screens are used.

621.397.6:621.385.832 3277
**High-Power Cathode-Ray Tubes**—Moss. (*See* 3308.)

621.397.6:621.395.625 3278
**Television Recording: Simplified System**—D. A. Smith. (*Wireless World*, vol. 55, pp. 305–306; August, 1949.) An economical system using a television receiver and a 16-mm film projector modified for use as a camera and sound recorder. Of every three television frames, two consecutive ones are photographed and the third is missed. A recording lamp for the sound signal is fed from the receiver output tube. For reproduction a standard projector with a 3-bladed shutter and running at 16 frames per second can be used.

621.397.6:621.396.615.17:621.317.755 3279
**Television Time Base Linearisation**—Keen. (*See* 3098.)

621.397.62 3280
**Television Receiver with Rimlock Valves and Automatic Frequency and Phase Control**—F. Juster. (*Radio Prof.* (Paris), vol. 18, pp. 11–15; June, 1949.) Complete circuit and component details for a receiver with an MW31-7 cr tube.

621.397.62 3281
**Designing a TRF [tuned radio frequency] Television Receiver**—W. H. Buchsbaum. (*Tele-Tech*, vol. 8, pp. 36–39; August, 1949.) The 15-tube receiver uses three metal rectifiers "B" supply and operates from ac or dc. A 2-tube rf amplifier and a four-stage video amplifier give high gain and performance nearly equal to those of superheterodyne receivers. Advantages and limitations of this type of receiver are discussed.

621.397.62 3282
**Transit-Time Effects in Television Front-End Design**—Watts. (*See* 3113.)

621.397.645 3283
**Television Stabilizing Amplifier**—Schultz. (*See* 3114.)

621.397.7 3284
**The Television Studio**—D. C. Birkinshaw. (*BBC Quart.*, vol. 4, pp. 105–117; July, 1949.) An account of studio technique used at the London television station, Alexandra Palace.

621.397.828 3285
**Television Interference Suppression**—"Spenny." (*RSGB Bull.*, vol. 25, p. 44; August, 1949.) Suppression of a 90-Mc harmonic from an amateur transmitter was effected by shunting the output by means of a $\lambda/2$ line .

621.397.828 3286
**TVI Reduction—Western Style**—C. E. Murdock. (*QST*, vol. 33, pp. 24–27, 82; August, 1949.) Interference caused by the harmonics of a 1-kW amateur transmitter 40 ft away from a television receiver was reduced by using high-capacitance tank circuits in the anode of the driver tube and single-turn coaxial pickup loops and high-capacitance grid circuits in the final amplifier. Antenna tuners were also built for each amateur band. Methods of suppressing interference due to line voltage fluctuations and keying clicks are also discussed.

621.397.828 3287
**The H.R.O. and T.V.I.**—R. L. Varney. (*RSGB Bull.*, vol. 25, pp. 41–42; August, 1949.) A strong third harmonic at the television frequency of 45 Mc is produced by the first heterodyne oscillator of the HRO communications receiver when operating in the 14-Mc band. This is suppressed by connecting a series resonant circuit between the oscillator tube cathode and earth.

## TRANSMISSION

621.396.61 3288
**A New 150-kW A.M. Transmitter**—T. J. Boerner. (*Broadcast News*, no. 55, pp. 42–49; June, 1949.) An efficient compact transmitter for the frequency range 540 to 1,600 kc, using class-B modulation of a class-C final amplifier. Details of design, layout, and installation are given and the results of performance tests are shown graphically and tabulated.

621.396.61 3289
**The Types TGM.651 and TGZ. 651 Transmitters**—W. J. Morcom. (*Marconi Rev.*, vol. 12, pp. 104–107; July and September, 1949.) Type TGM.651 is a 3-kW mf transmitter, and Type TGZ.651 a 3-kW mf and lf transmitter. These complete the series of which other members were noted in 553 of March (Cooper) and 1219 of May.

621.396.61:621.392.52 3290
**A Filter Design for the Single-Sideband Transmitter**—F. M. Berry. (*QST*, vol. 33, pp. 29–35; June, 1949.) A highly selective first if bandpass filter. Sharp cut-off is restricted to the hf side of the passband which extends from 17 to 20 kc. Basic design formulas are given for the filter which consists of two combined *m*-derived $\pi$ sections. Modifications permit operation directly from a ring modulator into the grids of a balanced tube modulator. The filter can be aligned with the minimum of special equipment.

621.396.61:621.396.8 3291
**Operation of A.M. Broadcast Transmitters into Sharply Tuned Antenna Systems**—W. H. Doherty. (Proc. I.R.E., vol. 37, pp. 729–734, July, 1949.) Investigation of the clipping of sidebands and distortion of the voltage envelope at high modulation frequencies. The effects may be reduced by suitable coupling methods.

621.396.61:621.396.97 3292
**The New 100-kW [broadcasting] Transmitter at Naples**—S. Bertolotti. (*Poste e Telecomun.*, vol. 17, pp. 44–46; January, 1949.) Distortion at 100 per cent modulation is within 2 per cent, the frequency curve is linear to within 2 db up to 10,000 cps, and background noise is at least 60 db down. Over-all efficiency is 39 per cent.

621.396.619.23 3293

**A High Voltage Ring Modulator**—M. J. Tucker. (*Electronic Eng.* (London), vol. 21, pp. 239–242; July, 1949.) A form of biased ring modulator using diodes provides a satisfactory precision "phase-conscious" rectifier for use at voltages high enough to enable the putput to be applied directly to the grid of an output stage. Practical circuits are discussed. See also 3542 and 3543 of 1948 (D. G. Tucker).

## TUBES AND THERMIONICS

537.291 3294

**Control of a Beam of Electrons by an Intersecting Electron Beam**—J. L. H. Jonker and A. J. W. M. Van Overbeek. (*Nature* (London), vol. 164, pp. 276–277; August 13, 1949.) Two electrode systems are arranged to produce two mutually perpendicular electron beams. The voltage applied to grid 1 determines the current in beam 1; this in turn controls the current in beam 2. A graph of the voltage of grid 1 against current to anode 2 is shown. The slope of this curve is more than twice that obtainable with normal direct grid control. It is suggested that replacing anode 2 by a secondary-emission multiplier would result in a slope of several amperes per volt at currents of the order of $10^{-2}$ A.

537.291+538.691]:537.525.92 3295

**Electron Flow in Curved Paths under Space-Charge Conditions**—Meltzer. (*See* 3120).

621.383 3296

**On a Method for the Production of Photo-Sensitive Layers of Very High Resistance with PbS as Infra-Red-Sensitive Semiconductor,**—K. Frank and K. Raithel. (*Z. Phys.*, vol. 126, pp. 377–382; May 27, 1949.) The layers are produced by vaporization of PbO in an atmosphere of sulphur vapor at low pressure, with subsequent heat treatment. Resistance is of the order of $10^{11}$–$10^{12}\Omega$ cm. The results of an investigation of such films by electron diffraction methods are discussed.

621.383:621.385.15 3297

**Electron-Multiplier Tubes. Developments. Use**—A. Lallemand. (*Jour. Phys. Radium*, vol. 10, pp. 235–239; July and September, 1949.) The fluctuation of the output current is determined for the ideal electron multiplier as a function of the number of stages and of the multiplication factor per stage. Other causes of current fluctuation are considered and a tube designed to eliminate such fluctuations as far as possible is described. The use of multiplier tubes with a very stable symmetrical amplifier, and also in a simple circuit including a neon lamp shunted by a capacitor, is discussed.

621.383:621.385.15:621.396.822 3298

**On the Variation of the Background Noise of a Photomultiplier RCA 931A with the Potential of the Glass Envelope**—C. Taylor. (*Jour. Phys. Radium*, vol. 10, pp. 255–256; July and September, 1949.) The background noise is multiplied by about 10 when the potential of the envelope differs from that of the photocathode by +500 or 1,000 V. A theory of the effect is proposed. For applications requiring low background noise, such as the counting of particles by scintillations, the envelope should be maintained at the potential of the photocathode.

621.383.4 3299

**Lead Sulfide Photoconductive Cells**—S. Pakswer. (*Electronics*, vol. 22, pp. 216, 218; August, 1949.) Correction to 2370 of September.

621.385 3300

**The Electron Wave Tube**—A. V. Haeff. (PROC. I.R.E., vol. 37, pp. 777–778; July, 1949.) Discussion on 1825 of July.

621.385 3301

**The Development of Radio Transmitting Valves**—J. Bell and J. W. Davies. (*GEC Jour.*, vol. 16, pp. 138–149; July, 1949.) The limitations of early types are discussed. New construction and manufacturing techniques which have largely overcome these limitations are described. Typical tubes are illustrated and their ratings and performance are tabulated.

621.385.032.29 3302

**The Calculation of the Electrode Temperatures in Radio Valves**—S. Wagener and I. A. Harris. (*Jour. Brit. I.R.E.*, vol. 9, pp. 318–319; August, 1949.) Comment on 1232 of May (Harris) and the author's reply.

621.385.3:621.396.645.029.3 3303

**A Low-Noise [audio] Input Tube**—C. R. Knight and A. P. Haase. (*Radio and Telev. News, Radio-Electronic Eng. Supplement*, vol. 12, pp. 15–18, 31; March, 1949.) Description of the double triode 12AY7, in which microphony effects and other noises are particularly low. A balanced amplifier, using these tubes in the first two stages and a 12AU7 in the output stage, with cross neutralization and inverse feedback, is also described and a detailed circuit diagram is given. The response curve is essentially flat from 30 cps to 20 kc.

621.385.38:621.317.3 3304

**The Deionization Time of Thyratrons: A New Method of Measurement**—Knight. (*See* 3186.)

621.385.832 3305

**Projective Three-Dimensional Displays: Parts 1 and 2**—D. M. MacKay. (*Electronic Eng.* (London), vol. 21, pp. 249–254 and 281–296; July and August, 1949.) A circuit is discussed which will perform two stages of rotation, one about the Y axis moving X to X′, and the second about the X′ axis. These rotations remove any structural ambiguities present in a given projection. Three methods of obtaining perspective convergence are given. A stereoscopic switching unit, and various methods for the relative measurement of projections are described. See also 577 of March (Parker and Wallis) and 1242 of May (Berkley).

621.385.832:535.371.07 3306

**The Physics of Cathode Ray Tube Screens**—Garlick. (*See* 3158.)

621.385.832:621.396.9 3307

**Three-Dimensional Cathode-Ray Tube Displays**—E. Parker and P. R. Wallis. (*Proc. IEE* (London), part III, vol. 96, pp. 291–294; July, 1949.) Discussion on 577 of March.

621.385.832:621.397.6 3308

**High-Power Cathode-Ray Tubes**—H. Moss. (*Wireless Eng.*, vol. 26, pp. 293–296; September, 1949.) A preliminary survey of the design of tubes with screen diameters up to 30 in. for direct viewing. The relation between the response of cascade screens and the beam voltage is uncertain and is of critical importance. Mechanical design difficulties are briefly discussed.

621.396.615.141.2 3309

**The Cavity Magnetron**—H. A. H. Boot and J. T. Randall. (*Proc. IEE* (London), part III, vol. 96, pp. 261–263; July, 1949.) Discussion on 890 of 1948.

621.396.822 3310

**Valve Noise and Transit Time**—C. J. Bakker. (*Wireless Eng.*, vol. 26, p. 277; August, 1949.) Comment on 2420 of 1948 (Campbell, Francis, and James). See also 255 of February, 583 of March (Houlding), and 3311 below.

621.396.822 3311

**Measurement of Induced Grid Noise**—F. L. H. M. Stumpers. (*Wireless Eng.*, vol. 26, pp. 277–278; August, 1949.) Discussion of recent experimental results which agree with those discussed by Bakker (3310 above and back references).

621.396.822 3312

**Transit-Time Effects in U.H.F. Valves**—J. Thomson. (*Wireless Eng.*, vol. 26, pp. 192–199; June, 1949, corrections **ibid.**, vol. 26, p. 278; August, 1949.) Mathematical technique suitable for cases, such as total-emission damping where space-charge distortion of the es field can be neglected. See also 3313 below.

621.396.822 3313

**Transit-Time Effects in U.H.F. Valves**—R. E. Burgess and J. Thomson. (*Wireless Eng.*, vol. 26, p. 313; September, 1949.) Burgess suggests that Bakker and de Vries (3374 of 1935) covered much of the work noted in 3312 above. Thomson regards their work as valid only for a simple idealization.

## MISCELLANEOUS

621.396 Popov 3314

**Alexander S. Popov**—G. W. O. H. (*Wireless Eng.*, vol. 26, pp. 249–250; August, 1949.) Reply to comment by Thornton (2113 of August) on 1842 of 1948.

652.6 3315

**Directory of Translators**—(*Jour. Franklin Inst.*, vol. 248, p. 104; July, 1949.) A directory of language specialists competent in various technical fields has been established by the Science-Technology Group of Special Libraries Association under the management of Mr. W. Kalenich, Librarian at the Southwestern Research Institute, San Antonio, Texas. About 3,000 technical translations already available in private files have also been listed.

621.396(031) 3316

**The Radio [amateur's] Handbook (Le Manuel Radio.) French edition** [Book Review]—Headquarters Staff of the American Radio Relay League. Publishers: P. H. Brans Antwerp, 1948, 350 pp., 240 fr. (Belgian). (*Alta Frequenza*, vol. 18, p. 88; April, 1949.) See also 2682 of October.

681.2 3317

**The Instrument Manual [Book Review]**—Publishers: United Trade Press, London, 548 pp., 70s. (*Electronic Eng.* (London), vol. 21, p. 310; August, 1949.) The book covers a very wide field. The majority of instruments and control gear described are mechanical, although electronic devices are not ignored. The text is in simple descriptive language, and many illustrative diagrams are given.

621.39 3318

**Wheeler Monographs**—A series of monographs appearing at two-monthly intervals, available on a subscription basis from Wheeler Laboratories, Inc., 122 Cutter Mill Road, Great Neck, N. Y. Single copies of each issue cost $25.00. All the monographs are by H. A. Wheeler except where otherwise stated. Titles of the first 11 monographs are:—1. Transmission Lines and Equivalent Networks. 2. Slide Rule Operations for Radio Problems. 3. A Simple Theory and Design Formulas for Superregenerative Receivers. 4. Geometric Relations in Circle Diagrams of Transmission-Line Impedance. 5. Generalized Transformer Concepts for Feedback Amplifiers and Filter Networks. 6. A Simple Theory of Powdered Iron at all Frequencies. 7. Superselectivity in a Superregenerative Receiver. 8. The Piston Attenuator in a Waveguide below Cut-off. 9. Measuring the Efficiency of a Superheterodyne Converter by the Input Impedance Circle Diagram, by H. A Wheeler and D. Dettinger. 10. The Transmission Efficiency of Linear Networks and Frequency Changers. 11. The Maximum Speed of Amplification of a Wide-Band Amplifier.

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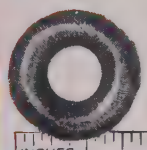

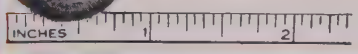


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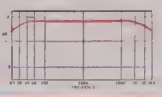

## HIGH FIDELITY OUTPUT TRANSFORMERS

| Type No | Primary matches following typical tubes | Primary Impedance | Secondary Impedance | ± ½db from | Maximum level |
|---|---|---|---|---|---|
| F1950 | Push pull 2A3's, 6A5G8s, 300A's, 275A's, 6A3's, 6L6's | 5000 ohms | 500, 333, 250, 200, 125, 50 | 20-30000 cycles | 15 watts |
| F1951 | Push pull 2A3's, 6A5G8s, 300A's, 275A's, 6A3's 6L6's | 5000 ohms | 30, 20, 15, 10, 7.5, 5, 2.5, 1.2 | 20-30000 cycles | 15 watts |
| F1954 | Push pull 245, 250, 6V6, 42 or 2A5 A prime | 8000 ohms | 500, 333, 250, 200, 125, 50 | 20-30000 cycles | 15 watts |
| F1955 | Push pull 245, 250, 6V6, 42 or 2A5 A prime | 8000 ohms | 30, 20, 15, 10, 7.5, 5, 2.5, 1.2 | 20-30000 cycles | 15 watts |
| F1958 | Push pull 6B5, 6A6, 53, 6F6, 59, 79, 89, 6V6, Class B 46, 59 | 10,000 ohms | 500, 333, 250, 200, 125, 50 | 20-30000 cycles | 15 watts |
| F1959 | Push pull 6B5, 6A6, 53, 6F6, 59, 79, 89, 6V6, Class B 46, 59 | 10,000 ohms | 30, 20, 15, 10, 7.5, 5, 2.5, 1.2 | 20-30000 cycles | 15 watts |
| F1962 | Push pull parallel 2A3's, 6A5G's, 300A's, 6A3's, 6L6 | 2500 ohms | 500, 333, 250, 200, 125, 50 | 20-30000 cycles | 36 watts |
| F1963 | Push pull parallel 2A3's, 6A5G's, 300A's, 6A3's, 6L6 | 2500 ohms | 30, 20, 15, 10, 7.5, 5, 2.5, 1.2 | 20-30000 cycles | 36 watts |
| F1966 | Push pull 6L6 or Push pull parallel 6L6 | 3800 ohms | 500, 333, 250, 200, 125, 50 | 20-30000 cycles | 50 watts |
| F1967 | Push pull 6L6 or Push pull parallel 6L6 | 3800 ohms | 30, 20, 15, 10, 7.5, 5, 2.5, 1.2 | 20-30000 cycles | 50 watts |

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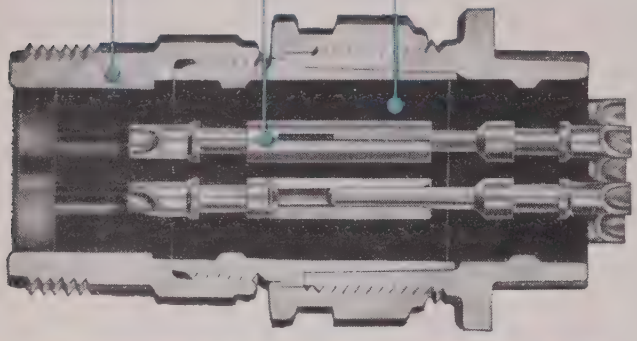

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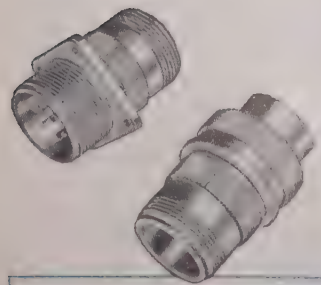

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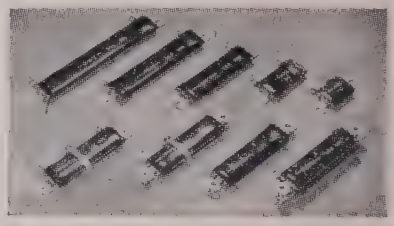
# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

## New Space-Saving Thin Resistor

A new, wire-wound, vitreous-enameled, thin-type resistor, which provides higher wattage per unit of space and is particularly useful when space is limited, has been developed by **Ohmite Mfg. Co.,** 4835 Flournoy St., Chicago 44, Ill.



This component is manufactured with either a single unit mounting-bracket, which allows mounting close to the surface, or with a stud bracket, which provides for stacking of two or more units. The brackets extend the entire length of the core, disbursing developed heat evenly throughout the resistor.

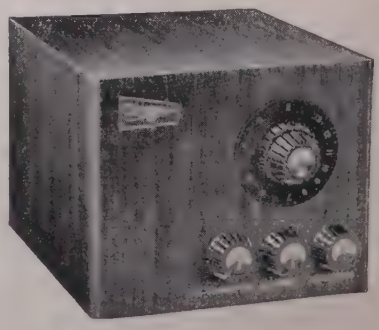
Irrespective of the type of bracket, the resistor may be obtained as a fixed component, or as an adjustable lug type, with which odd resistances may be obtained.

Lengths vary from $1\frac{1}{4}''$ for 30-watt size, to 6″ for 75-watt size. Five wattages are available, all in a wide range of resistance values.

The thin-type resistor is made to order only, and is fully described in bulletin 138.

## Remote Control TV Unit

A remote control unit designed to operate and control a TV receiver up to a distance of fifty feet has been put on the market by **Transvision, Inc.,** North Ave., New Rochelle, N. Y.



The manufacturer claims that this unit may be used with any receiver, and that it permits continuous tuning and coverage of all channels. This increases the function of early sets which have only 3- or 5-channel tuners. The unit has high gain with about 50-microvolt sensitivity, factory wired and tuned.

*(Continued on page 22A)*

# THESE NEW LONG-LIVED THYRATRONS LEAD FOR MOTOR-CONTROL APPLICATIONS

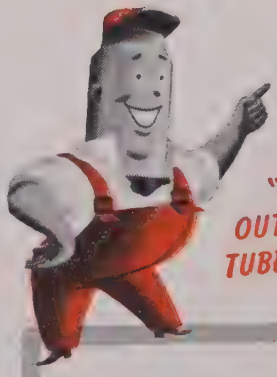
**With oversize gas charge to offset absorption from inductive loads**
**—high anode voltage**
**—high peak-to-average current ratio**
**—stable control characteristics**
**—short heating time**
**—"climate-proof" ambient temperature range**

SPECIFY General Electric's 3.2-amp GL-5544 or 6.4-amp GL-5545 for the motor-control unit now on your drawing-boards. Your equipment will benefit (no snubber circuit is needed with these tubes), while users will have the advantage and economy of full-measure tube life.

Both thyratrons have a charge of inert gas twice that of former types—sufficient to offset anode gas absorption caused by the inductive load in field and armature-control circuits.

Though of paramount value, this is but one of many improvements that put the GL-5544 and GL-5545 far ahead of other gas-filled thyratrons. Study the list of features above. Then add *strength of construction*. Key tube parts are internally braced; the grid-anode structure is solidly supported both at top and bottom. Add *electrical stability* . . . a special shielded-grid design cushions any grid effect from voltage surges. Here are dependable tubes you can count on to do a job where men are pushing machines hard for high production!

Help in applying the GL-5544 or GL-5545 to new motor-control circuits gladly will be given you by experienced G-E tube engineers. Phone your nearby G-E electronics office. Or wire or write *General Electric Company, Electronics Department, Schenectady 5, New York.*



"THEY OUTLAST AND OUT-PERFORM GAS-FILLED TUBES OF EARLIER DESIGN"

| | GL-5544 | GL-5545 |
|---|---|---|
| Filament voltage | 2.5 v | 2.5 v |
| Filament current | 12 amp | 21 amp |
| Peak anode voltage, forward and inverse | 1,500 v | 1,500 v |
| Peak cathode current | 40 amp | 80 amp |
| Avg cathode current | 3.2 amp | 6.4 amp |
| Current averaging time | 15 sec | 15 sec |
| Ambient temp range | −55 to +70 c | −55 to +70 c |

# GENERAL ELECTRIC

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Reeves leads the field in

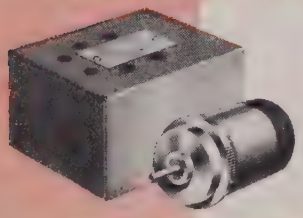
# Servo Component Design

Designed originally for our own precision control systems, these high performance units are now available to all.

## Reeves Servo Control Motors

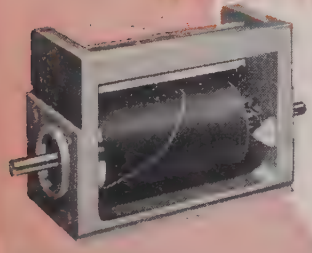
**Operating Directly** off the output tubes of a servo amplifier, these specially designed 60 and 400 cycle control motors completely **eliminate** use of bulky output transformers . . . **eliminate** transformer losses . . . permit use of smaller amplifier tubes . . . save weight, space, cost . . . have high corner frequency . . . high torque to inertia ratio. A.C. tachometers available in combination with motors or separately.

## Reeves 60 Cycle Electrical Resolvers



These newly developed units provide the most accurate and convenient means for solving trigonometric functions. The size 1 resolver, here illustrated, has over twice the accuracy of other available units — and is only 1/3 the size and weight of present types! Each resolver is matched with its own small compensating booster amplifier for peak performance.

## Reeves Functional Potentiometers



Potentiometer shaft rotation is transformed into a voltage corresponding to a rectangular or polar function. Any reasonable function may be easily installed with special function generating equipment in our plant. Function may be changed at any time by returning the potentiometer to Reeves with information on the new curve desired. Accuracy is within 0.05% at a 60° slope, and even finer at lesser slopes.

REEVES specializes in the development and manufacture of complete Electronic and Mechanical Control Systems, including Computing devices and Radar systems.

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INSTRUMENT CORPORATION

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For complete information write for catalog RICO-1F, "STANDARD INSTRUMENTATION PARTS AND SERVO-MECHANISM COMPONENTS".

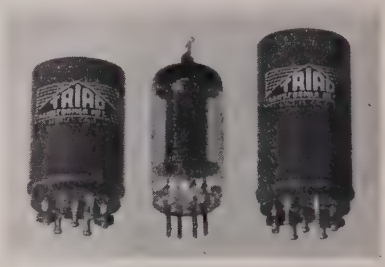
# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 14A)*

## Miniature Hermetically Sealed Transformers

The two new types of hermetically sealed audio transformers (shown on either side of 3S4 miniature tube for comparative size) can be designed to manufacturer's specifications by **Triad Transformer Mfg. Co.**, 423 N. Western Ave., Los Angeles 4, Calif.



Described as "Trijets," the type JO is $\frac{15}{16}$" in diameter, $1\frac{13}{16}$" in height, and $1\frac{1}{4}$ oz. in weight. Type JOA is $\frac{15}{16}$", by $1\frac{13}{32}$", and weighs $1\frac{1}{2}$ oz.

Transformers and reactors using this construction are custom-made in a wide variety of low-level and power applications. If necessary, 40-db alloy shielding will be supplied.

## New TV and X-Ray Volt Meter

The Model 4000, a kilovoltmeter designed to measure TV and X-ray voltages up to 50,000 volts dc is being manufactured by **Bradshaw Instrument Co.**, 348 Livingston St., Brooklyn 17, N. Y.

The Model 4000 is a 20-microampere meter with an input impedance of 1,250 megohms. All voltage is dissipated in the probe. The test leads are shielded, and the shields are joined to insure safety. A "Normal-Reverse" key is provided so that the probe may be used, regardless of the polarity of the voltage under test.

*(Continued on page 61A)*

# News—New Products

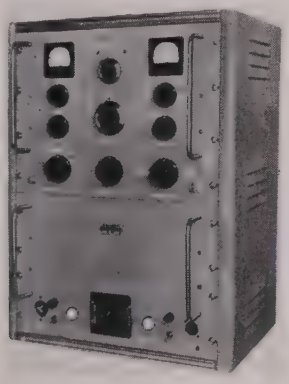
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 22A)*

AS EXHIBITED AT THE SPOTLIGHT ON THE NEW... I.R.E. RADIO ENGINEERING SHOW

## Klystron Power and Modulation Supply

The Type 801, a universal klystron power and modulation supply, which provides for cw, square-wave, saw-tooth, or external modulation of a wide variety of klystron oscillators, is being marketed by **Polytechnic Research & Development Co., Inc.**, 202 Tillary St., Brooklyn 1, N. Y.



The regulated beam supply is continuously variable in two steps from −800 to −3,600 volts dc, and offers a choice of operation of up to 1,500 volts at 65 Ma, or up to 3,600 volts at 25 Ma.

Both coarse and fine controls are provided on the front panel for continuous adjustment of the repeller voltage over the range from −20 to −750 volts. These controls are individually engraved to read repeller voltage directly to a precision of 1 volt. Additional controls provide both for grid voltage adjustment and for variation of both amplitude and repetition rate of the modulation signal.

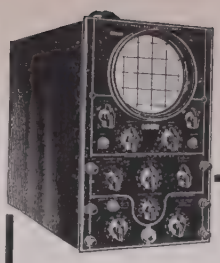
### NOTICE

Information for our News and New Products section is warmly welcomed. News releases should be addressed to **Industry Research Division, Proceedings of I.R.E., Room 707, 303 West 42nd St., New York 18, N.Y.** Photographs, and electrotypes if not over 2" wide, are helpful. Stories should pertain to products of interest specifically to radio engineers.

## Power Supply Delivers Regulation Within ½ Per Cent

A new compact power supply, Model 245, with regulation to within ½ per cent for both load and input variations, is now available for immediate delivery from **Kepco Labs., Inc.**, 149-14 41 Ave., Flushing, L. I., N. Y.

Specifications for dc output are 200 to 450 volts from 0 to 200 ma, regulated; ac output is 6.3 volts at 6 amperes, unregulated. Regulation between 200 and 450 volts for both load variation from 105 to 125 volts is better than 0.5 per cent. The dc output voltage is within 0.5 volts between 200 and 450 volts for load variations from 0 to 200 ma.

The combined features of the popular Du Mont Type 208-B have given it a greater volume of sales than any other cathode-ray oscillograph in the world.

**The Oscillograph that Outsells them all!**

***Versatile . . .***
Type 208-B is a general-purpose cathode-ray oscillograph, designed for both laboratory and industrial applications. Used extensively for receiver-test, strain-gage, pressure-measurement problems, and innumerable other applications.

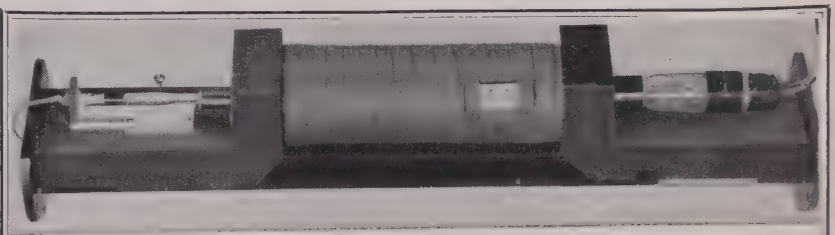
***Sensitive . . .***
Highest gain Y-axis amplifiers in any commercial oscillograph in its price range. Sensitivity, 10 millivolts rms per inch. Excellent low-frequency response. Recurrent sweep from 2 cps to 50,000 cps.

***Time-tested . . .***
For many successful years, the Du Mont Type 208-B has been the leader in its field. Improvements resulting from extensive field experience have been incorporated into its design.

***Moderately priced . . .***
The many applications of this instrument mean that it must meet varying budgets. Its low price and portability complete the requirements for an outstanding general-purpose oscillograph.

Instrument Division
ALLEN B. DU MONT LABS., INC.
1000 Main Ave., Clifton, N.J.

DUMONT



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**FOR LABORATORY AND EXPERIMENTAL USE**

*Operates in the vicinity of 3000 Mc/sec.*

SPECIFICATIONS

BANDWIDTH: 2700-3300 mc, flat to ± 1½ db

INPUT-OUTPUT CONNECTIONS: 1½" x 3" S-Band wave guide

GAIN AT 3000 MC: 23 db or greater

MODULATION LINEARITY: Linear up to 0.3 watt output

BEAM VOLTAGE: 2500 maximum

BEAM CURRENT: 20 ma maximum

NOISE FIGURE: 35 db or better

Focusing coils can be supplied over a reasonable range of voltages and currents

Klystrons, Traveling Wave and other Microwave Tubes designed and developed by VARIAN engineers to your specifications

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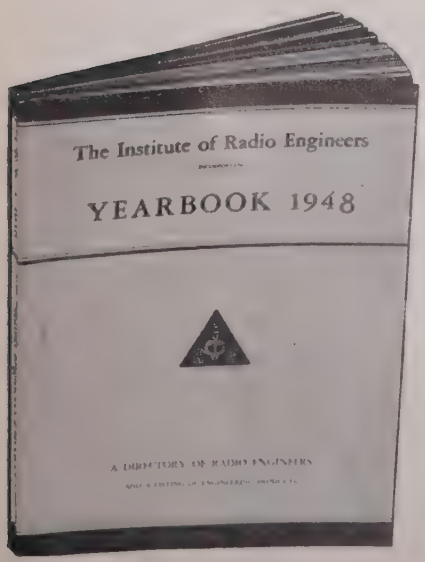
# Find products easily!

## Coming in the IRE Yearbook—

### 3347 Electronic Supply Firms Listed:

Every Firm in the alphabetical directory has address and complete line of products of interest to radio engineers is given in code numbers so you can understand what related products the firm supplies. This kind of listing gives you the most comprehensive and up-to-date picture of the company you are looking up, both as to manufactured products, and services. A cross-index provides direct reference to the page on which advertisers provide fuller information. Easy-reading type and spacing!




### Index of 75 Products and Services

This year, complete for companies who answered our requests, The Product Index shows ALL firms. Advertisers are given with complete addresses. A turn to alphabetical directory gives full data on the briefer listings.

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Fast Reference
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THE INSTITUTE OF RADIO ENGINEERS

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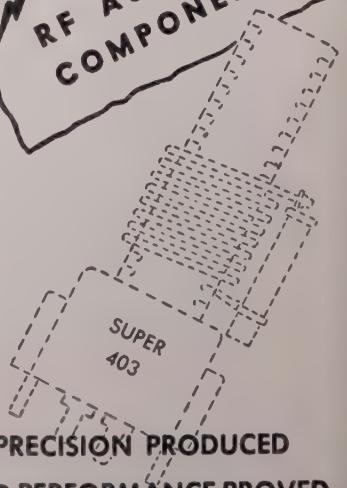
SUPER
RF AUDIO TV
COMPONENTS




**• PRECISION PRODUCED**
**• PERFORMANCE PROVED**

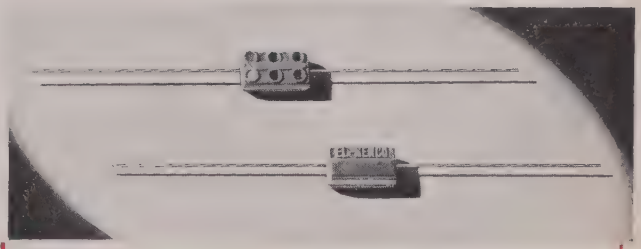
**SUPER ELECTRIC PRODUCTS CORP.**
*Pacing Electronic Progress With Ingenuity*
**1057 Summit Ave., Jersey City 7, N. J.**

EL-MENCO'S PLACE **in** YOUR PRODUCT

*Wherever fixed mica dielectric capacitors are used, the first choice with men of experience is always El-Menco*

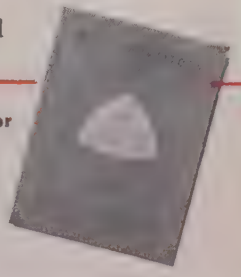
Precision-made under rigid conditions, tested seven ways to meet strict Army-Navy standards, thoroughly impregnated and provided in water-sealed low-loss bakelite; these tiny capacitors protect and maintain your reputation for quality equipment. To insure performance-excellence, place *El-Menco* capacitors in *your* product. Results will prove El-Menco to be a wise choice.

**THE ELECTRO MOTIVE MFG. CO., Inc.**
WILLIMANTIC CONNECTICUT



**CM 15 MINIATURE CAPACITOR**

Actual Size $\frac{9}{32}$" x $\frac{1}{2}$" x $\frac{3}{16}$"
For Radio, Television and Other Electronic Applications
2 to 420 mmf. capacity at 500v DCw
2 to 525 mmf. capacity at 300v DCw
Temp. Co-efficient ±50 parts per million per degree C for most capacity values
6-dot standard color coded



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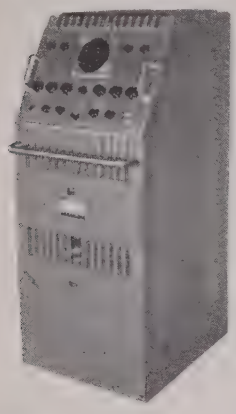
RCO ELECTRONICS, INC. 135 Liberty St., New York, N. Y.—Sole Agent for Jobbers and Distributors in U.S. and Canada

# NEWS and NEW PRODUCTS

AUGUST, 1949

## 50-Mc TV Oscilloscope

The FTL-32A a broad-band TV oscilloscope, which records wave forms having frequency components as high as 50 Mc and as low as 10 cps, is presented by **Federal Telecommunications Labs., Inc.,** 500 Washington Ave., Nutley 10, N. J.



This wide-band frequency response is obtained with sufficient amplification to provide deflection sensitivity of 0.1 peak-to-peak volts per inch. The horizontal amplifier has a bandwidth of 10 cps to 10 Mc.

Both repetitive and triggered sweeps are incorporated with time durations consistent with the 50 Mc bandwidth. Synchronization from an internal or external source is independent of the synchronization signal amplitude, provided a minimum of 0.1 volt is exceeded.

## New Traveling-Wave Amplifier

A new addition to their line, Model 202 Wide Band Chain Amplifier, a traveling-wave type, is announced by **Spencer-Kennedy Labs., Inc.,** 186 Massachusetts Ave., Cambridge 39, Mass.

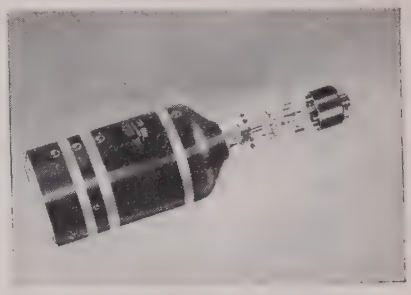
The model 202 has 2 stages of six 6AK5 tubes, gain of 20 db, bandwidth of 200 Mc. SWR is less than 1.5 db, and transmission characteristic is ±1.5 db from 100 kc to 200 Mc at an impedance level of 200 ohms.

The amplifier employs a traveling-wave circuit to achieve its wide bandwidth; thus it is adaptable for use with signal, pulse, and sweep generators, vacuum-tube voltmeters, and TV test equipment.

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

## Sensitive Multiple-Intensifier Type Cr Tube

A new multiple-intensifier type cathode-ray tube featuring a highly sensitive vertical-deflection system, and known as the Type 5XP-, is announced by **Allen B. Du Mont Laboratories, Inc., Instrument Div.,** 1000 Main Ave., Clifton, N. J.



Potentials as low as 24 to 36 volts peak-to-peak are sufficient for 1″ vertical deflection on the screen. Even though the Type 5XP employs high accelerating potentials, the manufacturer claims its deflection factor for plate-pair $D_3$-$D_4$ is but one-third of the deflection factor of similar tubes operating at low accelerating potentials.

A new type of deflection-plate structure is used in which the length of one pair of plates is considerably increased while the width is decreased. Because of this new deflection-plate design, the greater sensitivity of the tube is achieved with a plate-to-plate capacitance of only 1.7 $\mu\mu$f. A $\frac{7}{8}$″ increase in the over-all length of the tube is also a contributing factor to the high deflection sensitivity.

## Improved Glass-Metal Seal for Waveguide Windows

Glass waveguide windows, designed to permit silver soldering (without damage) to micro-waveguide systems operating at frequencies from 3,000 to 40,000 Mc, have been announced by **Electronics Div., Sylvania Electric Products Inc.,** 500 Fifth Ave., New York 18, N. Y.

Development of these resonant windows, in which glass stress is eliminated at relatively high temperature differentials required for soldering, makes available a wide range of window shapes and outside contours, for narrow- and wide-band transmissions. Power losses range from 0.02 to 0.1 db. For frequencies above 3,500 Mc, the windows will stand pressures up to 65 pounds per square inch absolute.

## Continuous Loop Drive Tape Recorder Mechanism

Continual repetition of any recorded message, from 4 seconds to 10 minutes duration, is possible through the use of a continuous loop drive mechanism, available as optional equipment on any standard Twin-Trax Tape recorder, by **Twin-Trax Div., Amplifier Corp. of America,** 398-1 Broadway, New York 13, N. Y.

This mechanism is detachable to facilitate installation on previously purchased Twin-Trax models.

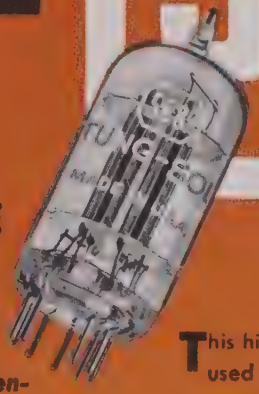
Two variations of the drive are available. The model CL-3 will record and play back information from 4 seconds to 3 minutes in duration. During operation, a sufficient length of tape is spooled on a stationary hub. The inside layer of tape is fed through a slot in the hub, past an idler, past the record-playback head, and subsequently engaged by the pulling capstan. The beginning of the tape is then joined to the end to form a continuous loop which will continue to repeat until it is manually or automatically shut off.

Model Cl-10 will reproduce information from 4 seconds to 10 minutes, and operates on the same principle, but utilizes a storage system with lower inherent friction which is accomplished with ball bearing rollers.

*(Continued on page 24A)*

# TUNG-SOL 5687

## A MINIATURE TWIN TRIODE WITH UNEQUALLED PERFORMANCE CAPABILITIES



1. *Exceptionally high perveance and tremendous reserve emission.*
2. *Out-performs all other tubes of its class.*
3. *Performance potential equivalent to two-and-a-half times that of a 6SN7GT tube.*
4. *On the Army-Navy Preferred List.*

This high-performance general-purpose tube may be used as a power amplifier, as a cw, or pulsed oscillator, and as a cathode follower. It is equally useful in balanced circuits, as a modulator or a servo amplifier and in the countless other applications for which twin triodes are so suitable. It is painstakingly produced under laboratory conditions. Each part is individually inspected and tested and every step of assembly is rigidly held to highest standard. The result is exceptional uniformity and reliability.

### RATINGS

*Interpreted according to RMA standard M8-210*

| | | | |
|---|---|---|---|
| Heater Voltage (± 10%) | 12.6 | 6.3 | VOLTS |
| Maximum Heater-Cathode Voltage | 90 | | VOLTS |
| Maximum Plate Voltage | 300 | | VOLTS |
| Maximum Inverse Plate Voltage | 1000 | | VOLTS |
| Maximum Plate Dissipation (each unit) | 4.2 | | WATTS |
| Maximum Total Plate Dissipation (both units) | 7.5 | | WATTS |
| Maximum Bulb Temperature (at any part of envelope) | 220° | | C |
| Maximum DC Grid Current (each unit) | 6 | | MA. |
| Maximum External Grid Circuit Resistance (each unit) | 1 | | MEG. |

### CHARACTERISTICS

*Class $A_1$ Amplifier—Each Unit*

| | | | | |
|---|---|---|---|---|
| Heater Voltage | 12.6 | 6.3 | | VOLTS |
| Heater Current | 450 | 900 | | MA. |
| Plate Voltage | 120 | 180 | 250 | VOLTS |
| Grid Voltage | −2 | −7 | −12.5 | VOLTS |
| Plate Current | 36 | 23 | 16 | MA. |
| Plate Resistance | 1650 | 2750 | 4000 | OHMS |
| Transconductance | 11000 | 6400 | 4100 | μMHOS |
| Amplification Factor | 18 | 17.5 | 16.5 | |
| Grid Voltage (approx.) For $I_b$—100 μA | −10 | −15 | −21 | VOLTS |

*For more complete information about the 5687, write for these bulletins.*

**TUNG-SOL ELECTRON TUBES**

The Tung-Sol engineering which has produced the 5687 is constantly at work on a multitude of special electron tube developments for industry. Many exceptionally efficient general and special purpose tubes have resulted. Information about these and other types are available on request to Tung-Sol Commercial Engineering Department.

**TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY**

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*Also Mfrs. of:* RECEIVING TUBES, MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS and CURRENT INTERMITTORS

# Triad Transformers Now Stocked by Distributors

TRIAD TRANSFORMERS

## Formerly Available Only as Components of Fine Electronic Equipment

Thoroughly tested and proved by years of exacting performance requirements on original equipment, Triad Transformers are designed and built to meet these specific applications:

**ORIGINAL EQUIPMENT**—TRIAD 'HS' transformers for original equipment embody superior techniques in transformer design and construction—*power transformers* of low temperature rise and good regulation—*chokes* of low resistance and high inductance—*audio transformers* of wide range both in frequency response and in power-handling capacity. Such transformers deserve the best in mechanical construction and protection against failure as exemplified by TRIAD's perfected hermetic sealing. Quantity production of hermetically sealed transformers for our Armed Services under JAN specifications has resulted in improved production techniques, and has lowered costs on these exceptionally long-lived units to permit their use in quality electronic apparatus.

**REPLACEMENT**—TRIAD is a major source of transformers for radio and television manufacturers. TRIAD replacement transformers, therefore, incorporate many parts and features to make them readily and universally adaptable to vacant spots in these chassis. Features include: High-quality materials, permitting small size without excessive temperature rise; vacuum varnish impregnation of both coil and core, copper foil static shields in all power coils, heavy drawn steel cases with sturdy baked enamel finish,and high temperature UL approved lead materials.

**GEOPHYSICAL**—TRIAD "Geoformers" are individually calibrated components for incorporation in 5-500 cycle measuring equipment of laboratory precision. Inductance is held within ±5% for the entire production and frequently within ± 2% for any given shipment of transformers. "Geoformers" incorporate hum-bucking coils and multiple alloy shielding for minimum pickup; are of minimum size and weight, and are vacuum-filled and hermetically sealed. Designs are based on years of specialization in this difficult field by pioneers in geophysical transformer design. Standard designs for use in the most used circuits are carried in stock at the factory and by TRIAD distributors. Complete specifications for "Geoformers" are given in TRIAD Bulletin GP-49, available on request.

**AMATEUR**—TRIAD "DX'er" line of amateur transformers have been built around high-production, low-cost, transformer parts and simple coil constructions. This permits designs employing liberal quantities of high-quality material, at reasonable cost. Simple one-purpose designs with drawn steel cases and flexible leads eliminate much of the unnecessary cost involved in heavy castings and expensive tapped coil constructions, while still permitting extensive use of finest materials essential to good transformer design.

**Write for Triad Transformer Catalog TR-49. Some territories still open for qualified manufacturers' agents.**

BOOTH 74

5th Annual Pacific Electronic Exhibit

August 30, 31 and September 1

San Francisco Civic Auditorium

TRIAD TRANSFORMER MFG. CO.

2254 SEPULVEDA BLVD. · LOS ANGELES 25, CALIFORNIA


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 14A)*

## Dc Microammeter and Magnetic Amplifier

A new microammeter, Type 100, designed to measure low dc is announced by **W. S. MacDonald Co., Inc.,** 33 University Rd., Cambridge 38, Mass.

The Type 100 has an input resistance of 50 ohms and a sensitivity of 1 ma full scale. The input may be overloaded ½ ampere without causing damage. Unlike high sensitivity galvanometers, this instrument is not sensitive to position or vibration.

An output jack is provided so that the instrument can be used as dc amplifier; as such it will actuate a 1-ma 1,400-ohm recorder directly.

## Rf Alignment and TV Marker Generator

A new addition to their line of test equipment, the Model 320 Signal Generator, is announced by **Electronic Instrument Co., Inc.,** 276 Newport St., Brooklyn 12, N. Y.

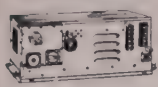
Designed for use in all phases of the radio industry, the Model 320 may be used for FM-AM alignment and to provide TV marker frequencies. The meter features a Hartley oscillator with a range of of 150 kc to 100 Mc, with fundamentals to 34 Mc. A Colpitts type audio oscillator supplies 400 cps sine wave voltage for modulation.

As are the majority of Eico products, this model is also available as a kit.

*(Continued on page 47A)*

**3 CM RECEIVER**

**SO-3. Complete With W.G. Mixer Assy (723 A/B) Reg. Fil. Power Supply, 6 Stages IF (6AC7) .....$99.50**



**3 CENTIMETER**
**(STD. 1" x ½" GUIDE, UNLESS OTHERWISE SPECIFIED)**

**3 cm. 180° bend** with pressurizing nipple .....$4.00 ea.
**3 cm. 90° bend.** 14" long 90° twist with pressurizing nipple .....$4.00 ea.
**3 cm. "S" curve** 18" long .....$5.50 ea.
**3 cm. "S" curve** 6" long .....$3.50 ea.
**3 cm. right angle bends.** "E" plane 18" long cover to cover .....$6.50 ea.
**3 cm. Cutler feed dipole.** 11" from parabola mount to feed back .....$8.50 ea.
**3 cm. directional coupler.** One way waveguide output .....$15.00 ea.
**ATR section** for mounting 1B24 with 721A ATR cavity. Iris coupling flange. Choke to choke .....$12.50 ea.
**APS-31 mixer section** for mounting two 2K25's Beacon reference cavity 1B24 TR tube. New and complete with attenuating slugs $42.50 ea.
**DUPLEXER SECTION** for 1B24 .....$10.00
**CIRCULAR CHOKE FLANGES,** solid brass .55
**SQ. FLANGES, FLAT BRASS** .....ea. .55
**APS-10 TR/ATR DUPLEXER** section with additional iris flange .....$10.00
**FLEX. WAVEGUIDE** .....$4.00/Ft.
**TRANSITION 1 x ½ to 1¼ x ⅝, 14 in. L** ..$8.00
**"X" BAND PREAMPLIFIER,** consisting of 2-723 A/B local oscillator-beacon feeding waveguide and **TR/ATR** Duplexer sect, inc. 60 mc **IF** amp .....$42.50
**Random Lengths** waveguide, 6" to 18" Lg. **$1.10 Ft.**
**WAVEGUIDE RUN, 1¼" x ½" guide,** consisting of 4 ft. section with Rt. angle bend on one end 2" 45 deg. bend other end .....$8.00
**WAVEGUIDE RUN, 1¼" x ½" guide,** consisting of 4 ft. long .....$10.00
**"X" BAND PRESSURIZING** gauge section w/15-lbs. gauge & Pressurizing Nipple .....$18.50
**45 DEG. TWIST** 6" Long .....$10.00
**ROTARY JOINT** with slotted section and type "N" output pickup .....$17.50
**WAVEGUIDE SECTION,** 12" long choke to cover 45 deg. twist & 2½" radius, 90 deg. bend $4.50
**SLUG TUNER/ATTENUATOR,** W.E. guide, gold plated .....$6.50
**TWIST** 90 deg. 5" choke to Cover w/press nipple .....$6.50
**WAVEGUIDE SECTIONS** 2½ ft. long silver plated with choke flange .....$5.75
**ROTARY JOINT** choke to choke .....$17.50
**ROTARY JOINT** choke to choke with deck mounting .....$17.50
**3 cm. mitred elbow** "E" plane unplated.... .....$6.50 ea.

**5CM.**

**2" x 1" RT. ANGLE BEND CHOKE** TO COVER. SILVER PLATER .....$38.50
**WAVEGUIDE MIXER** CV-12A/APR-6 ....$55.00
**RAPID W. G. FASTENING CLAMPS** .....$5.00

**MAGNETRONS**

| Tube | Frq. Range | Pk. Pwr. Out | Price |
|---|---|---|---|
| 2J31 | 2820-2860 mc. | 265 KW. | $25.00 |
| 2J21-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 2J22 | 3267-3333 mc. | 265 KW. | $25.00 |
| 2J26 | 2992-3019 mc. | 275 KW. | $25.00 |
| 2J27 | 2965-2992 mc. | 275 KW. | $25.00 |
| 2J32 | 2780-2820 mc. | 285 KW. | $25.00 |
| 2J37 | | | $45.00 |
| 2J38 Pkg. | 3249-3263 mc. | 5 KW. | $35.00 |
| 2J39 Pkg. | 3267-3333 mc. | 87 KW. | $35.00 |
| 2J40 | 9305-9325 mc. | 10 KW. | $65.00 |
| 2J49 | 9000-9160 mc. | 58 KW. | $85.00 |
| 2J34 | | | $55.00 |
| 2J61 | 3000-3100 mc. | 35 KW. | $65.00 |
| 2J62 | 2914-3010 mc. | 35 KW. | $65.00 |
| 3J31 | 24,000 mc. | 50 KW. | $55.00 |
| 5J30 | | | $39.50 |
| 714AY | | | $25.00 |
| 718DY | | | $25.00 |
| 720BY | 2800 mc. | 1000 KW. | $50.00 |
| 720CY | | | $50.00 |
| 725-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 730-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 728 | AY, BY, CY, DY, EY, FY, GY | | $50.00 |
| 700 | A, B, C, D | | $50.00 |
| 706 | AY, BY, DY, EY, FY, GY | | $50.00 |
| Klystrons. | 723A/B $12.50; 707B W/Cavity 417A $25.00 | 2K41 | $20.00 $65.00 |

**COMMUNICATIONS EQUIPMENT CO.**

**131 "I 8" Liberty St., New York, N.Y.**

**MAGNETRON MAGNETS**

| Gauss | Pole Diam. | Spacing | Price |
|---|---|---|---|
| 4850 | ¾ in. | ⅝ in. | $12.50 |
| 5209 | 21/32 in. | ¾ in. | $17.50 |
| 1300 | 1⅝ in. | 1 5/16 in. | $12.50 |
| 1860 | 1⅝ in. | 1½ in. | $14.50 |

**Electromagnets for magnetrons .....$24.50 ea.**

**TUNABLE PKGD. "CW" MAGNETRONS**

**QK 61** 2975-3200 mc. **QK 62** 3150-3375 mc.
**QK 60** 2800-3025 mc. **QK 59** 2675-2900 mc.
**New, Guaranteed .....Each $65.00**

**PULSE EQUIPMENT**

**PULSE TRANSFORMERS**

**G.E.K.-2745** .....$39.50
**G.E.K.-2744-A.** 11.5 KV High Voltage, 3.2 KV Low Voltage @ 200 KW oper. (270 KW max.) 1 microsec. or ¼ microsec. @ 600 PPS $39.50
**W.E. #D166173** Hi-Volt input transformer, W.E. Impedance ratio 50 ohms to 900 ohms. Freq. range: 10 kc to 2 mc. 2 sections parallel connected, potted in oil .....$36.00
**W.E. KS** 9800 Input transformer. Winding ratio between terminals 3-5 and 1-2 is 1.1:1, and between terminals 6-7 and 1-2 is 2:1. Frequency range: 380-520 c.p.s. Permalloy core .....$6.00
**G.E. #K2731** Repetition Rate: 635 PPS, Pri. Imp: 50 Ohms. Sec. Imp: 450 Ohms. Pulse Width: 1 Microsec. Pri. Input: 9.5 KV PK. Sec. Output: 28 KV PK. Peak Output: 800 KW. Riflar 2.75 Amp. .....$64.50
**W.E. #D169271** Hi Volt input pulse Transformer .....$27.50
**G.E. K2450A.** Will receive 13KV. 4 micro-second pulse on pri., secondary delivers 14KV. Peak power out 100KW G.E. .....$4.50
**G.E. #K2748A,** Pulse Input, line to magnetron .....$36.00
**#9280 Utah** Pulse or Blocking Oscillator XFMR Freq. limits 790-810 cy-3 windings turns ratio 1:1:1 Dimensions 1 13/16 x 1⅛" 19/32 ...$1.50

**PULSE NETWORKS**

**15A**—1-400-50: 15 KV, "A" CKT, 1 microsec., 400 PPS, 50 ohms imp. .....$42.50
**G.E. #6E3-5-2000-50P2T,** 6KV, "E" circuit, 3 sections, .5 microsecond, 2000 PPS, 50 ohms impedance .....$6.50
**G.E. #3E** (3-84-810; 8-2.24-405) 50P4T; 3KV, "E" CKT Dual Unit: Unit 1, 3 Sections. .84 Microsec.
**810 PPS,** 50 ohms imp.: Unit 2, 8 Sections, 2.24 microsec. 405 PPS, 50 ohms imp. .....$6.50
**7.5E3-1-200-67P.** 7.5 KV, "E" Circuit, 1 microsec. 200 PPS, 67 ohms impedance, 3 sections .$7.50
**7.5E4-16-60.67P.** 7.5 KV, "E" circuit, 4 sections, 16 microsec. 60 PPS, 67 ohms impedance $15.00
**7.5E3-3-200-6PT.** 7.5 KV, "E" Circuit, 3 microsec. 200' PPS, 67 ohms imp., 3 sections ....$12.50

**DELAY LINES**

**D-168184:** .5 microsec. up to 2000 PPS, 1800 ohm term. .....$4.00
**D-170499:** .25/.50/.75, microsec. 8 KV. 50 ohms imp. .....$16.50
**D-165997:** 1¼ microsec. .....$7.50

**MODULATOR UNIT BC 1203-B**

Provides 200-4,000 PPS, Sweeptime: 100 to 2,500 microsec. in 4 steps fixed mod. pulse, suppression pulse, sliding modulating pulse, blanking voltage, marker pulse, sweep voltages, calibration voltages, fil. voltages. Operates 115 vac. 50-60 cy. Provides various types of voltage pulse outputs for the modulation of a signal generator such as General Radio #804B or #804C used in depot bench testing of SCR 695, SCR 595, and SCR 535. New as shown .....$125.00
**MIT. MOD. 3 HARD TUBE PULSER:** Output Pulse Power: 114 KW (12 KV at 12 amp.). Duty Ratio: .001 max. Pulse duration, 5, 1.0 2.0 microsec. input voltage: 115 v. 400 to 2400 cps. Uses 1-715-B, 1-829-B, 3-'72's, 1-'73. New .....$110.00
**APQ-13 PULSE MODULATOR.** Pulse Width .5 to 1.1 Micro. Sec. Rep. rate 624 to 1348 Pps. Pk. pwr. out 35 KW. Energy 0.018 Joules .....$49.00
**TPS-3 PULSE MODULATOR.** Pk. power 50 amp. 24 KV (1200 KW pk): pulse rate 200 PPS, 1.5 microsec., pulse line impedance 50 ohms. Circuit—series charging version of DC Resonance type. Uses two 705-A's as rectifiers. 115 v. 400 cycle input. New with all tubes .....$49.50
**APS-10 MODULATOR DECK.** Complete, less tubes .....$75.00
**APS-10** Low voltage power supply, less tubes .....$18.50

**BC 1277A** Sig. Generator .....$300.00
**APR4.** Receiver 300-2000 mc. .....$475.00
**CPD 10137** Dehydrating Unit .....$425.00
**APR5A.** Complete antenna. 10 cm. waveguide .....$185.00
**Sylvania** 10 cm. Sig. Generator using 707B W/WG below cutoff attenuator ..$325.00

*(Continued from page 45A)*

Niemann, L. H., Sylvania Electric Products Corp., 500 Fifth Ave., New York 18, N. Y.
Orlowski, E., 4755 N. Malden Ave., Chicago 40, Ill.
Palester, J. J., 68-36 Burns St., Forest Hills, L. I., N. Y.
Richards, C. I., 2321 Rosemont Ave., Chicago 45, Ill.
Rollick, W. D., 1001 Knollwood Ave., Winston-Salem, N. C.
Rymas, S. J., 2911 W. 40 St., Chicago 32, Ill.
Salapatek, F. C., 12821 Winchester St., Blue Island, Ill.
Sandor, J., 7818 Goll Ave., N. Hollywood, Calif.
Sargent, H. P., Jr., 301 Warren St., Needham 92, Mass.
Shepherd, L., 330 E. Howard St., Albuquerque, N. Mex.
Showalter, R. L., 2035 W. 259 Pl., Lomita, Calif.
Siegel, S., 5050 N. Broadway, Chicago 40, Ill.
Skoff, J., Jr., Box 119A, St. Clairsville, Ohio
Smith, E. L., Jr., 3448 Caton Ave., Baltimore 29, Md.
Stanonis, A. F., 4837 Wright Terr., Skokie, Ill.
Stevens, T. E., 350 Stanton St., Pasadena 3, Calif.
Strom, L. D., 57-45 225, Little Neck, L. I., N. Y.
Strong, E. H., 187 Kelley St., Manchester, N. H.
Stubner, J. W., 2116 Grove St., Glenview, Ill.
Stumpers, F. L. H. M., 7 Nachtegaallaan, Eindhoven, Holland
Sugimoto, J., 1420 N. Larrabee, Chicago 10, Ill.
Sullivan, J. L., 5123 Fulton St., Chicago, Ill.
Surprenant, A., 81 Newton St., West Boylston, Mass.
Swanson, W. G., 5263 W. North Ave., Chicago 39, Ill.
Titus, R. W., 2722 N. Wayne Ave., Chicago 14, Ill.
Tyberg, A. H., 2716 W. Eighth St., Cincinnati 5, Ohio
Veronica, D. J., 45 Nevada Ave., Buffalo, N. Y.
Walcher, J. F., 1525 Maple Ave., Wyoming, Ohio
Warner, W. V., 112 Orchid Rd., Levittown, Hicksville, N. Y.
Warren, R. M., 87 Bay State Rd., Arlington 74, Mass.
Weber, M. E., 5625 Eskridge St., Houston 3, Tex.
Weinsheimer, W. E., 836 Chalker St., Akron 10, Ohio
Werner, W. F., 72 St. James Pl., Brooklyn 5, N. Y.
West, R. E., 1638 Kepzie Ave., Chicago 47, Ill.
White, S. A. A., 74 Huron Ave., Cambridge, Mass.
Wisner, C. V., Jr., 6726 S. Oglesby Ave., Chicago, Ill.
Wodzinsky, W. T., 202 Broadway St., Carnegie, Pa.
Womack, R. H., 124A Grosvenor, Inglewood, Calif.
Zawada, J. D., Chicago Technical College, 2000 S. Michigan Ave., Chicago, Ill.

# News—New Products

**These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.**

*(Continued from page 24A)*

## Recent Catalogs

• • • A new 49-page catalog in color describing their complete line of relays, classified according to purpose and by contact ratings, by **Leach Relay Co.,** 5915 Avalon Blvd., Los Angeles 3, Calif.

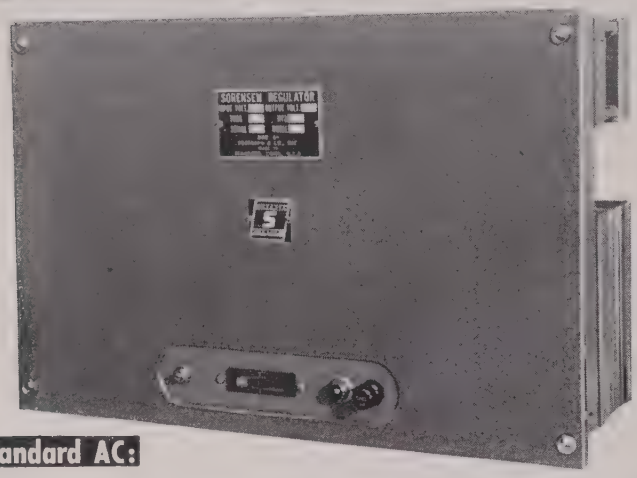
• • • A listing of over 400 transformers and related components has just been released, and is available to interested firms, by **Standard Transformer Corp.,** Elston, Kedzie & Addisons Sts., Chicago 18, Ill.

*(Continued on page 48A)*

# electronic voltage regulators by sorensen

**MAXIMUM ACCURACY**

**MINIMUM DISTORTION • FREQUENCY INSENSITIVITY**



**Standard AC:**

| Model in VA Capacity | 150<br>500 | 250<br>1000 | 2000<br>3000 | 5000<br>10000<br>15000 |
|---|---|---|---|---|
| Regulation — Basic | 0.5% | 0.2% | 0.2% | 0.5% |
| Accuracy — S | 0.2% | 0.1% | 0.1% | 0.2% |
| Harmonic — Basic<br>Distortion — S | 5% max<br>3% max | 5% max<br>2% max | 5% max<br>3% max | 5% max<br>3% max |
| Input voltage | 95-125 VAC also available for 190-250 VAC single phase 50-60 cycles | | | |
| Output voltage | adjustable between 110-120; 220-240 in 230 VAC models | | | |
| Load range | From 0.1 load or no load ("0" models) at rated accuracy | | | |
| P.F. range | Down to 0.7 P.F. all S models temperature compensated | | | |

NOTE: Regulators can be hermetically sealed

**Standard DC:**

| * Output voltage | 6 | 12 | 28 | 48 | 125 |
|---|---|---|---|---|---|
| ** Load in amperes | 5-15-40-100 | 5-15-50 | 5-10-30 | 15 | 5-10 |
| Input voltage | 95-125 VAC single phase 50-60 cycles: adapter available for 230 VAC operation | | | | |
| Regulation Accuracy | 0.25% from ¼ (or no load in "O" models) to full load | | | | |
| Ripple voltage RMS Max | 1% | | | | |
| Recovery time | 0.2 seconds — value includes charging time of filter circuit for the most severe change in load or input conditions | | | | |

* Adjustable +10%, —25%

** Individual models identified by indicating output voltage first then amperes. Example: E-6-5 6 VDC @ 5 amperes

**SPECIALS** Your particular requirements can be met by employing the ORIGINAL SORENSEN CIRCUIT in your product or application. SORENSEN REGULATORS can be designed to meet JAN specifications. SORENSEN engineers are always available for consultation about unusual regulators to meet special needs not handled by *THE STANDARD SORENSEN LINE.*

*Write for complete literature*

Sorensen and company, inc.

375 Fairfield Ave., Stamford, Connecticut

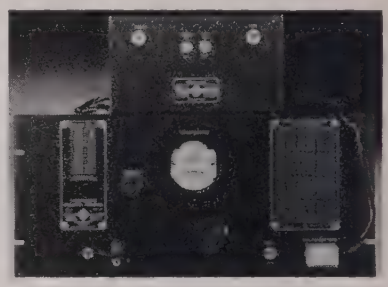

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 47A)*

## Interpolator for Uhf Measurements

The Model 1110-A, Interpolating Frequency Standard, designed for use with heterodyne frequency meters in making measurements at uhf up to about 3,000 Mc, is announced by **General Radio Co.**, 275 Massachusetts Ave., Cambridge 39, Mass.



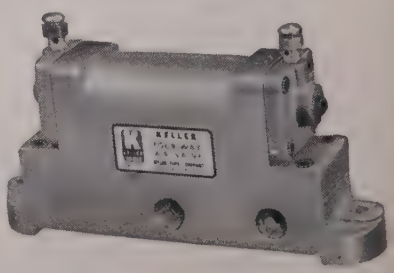
The manufacturing engineers claim that when it is used with a meter, whose accuracy is 0.1 per cent, the accuracy is increased to 0.001 per cent. The Model 1110-A was designed for use with General's Type 720-A heterodyne frequency meter which has a range of 100 to 200 Mc. Frequencies up to 3,000 Mc are measured by using harmonics of the 720-A.

An additional series of harmonics, based on 0.1 Mc fundamental, is also generated, for use with type 620-A meter, in measuring the range between 10 and 300 Mc.

## Four-Way Air Valve

A new line of four-way air valves of the balanced piston type is announced by the **Keller Tool Co.**, Grand Haven, Mich.

The valve is actuated by poppet-type control buttons which exhaust air from either end of a balanced piston. The piston is used only as a means of operating a faced slide valve, which is the actual seal for directional control of the flow of air.



A few of the new design features incorporated are: a slide valve of oil resistant rubber (which, the manufacturer claims, have sealing surfaces that improve with use); a stainless steel piston for moving the slide valve; all pipe connections are located in the base, so that working parts are accessible without disconnecting the air lines.

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

These air valves are available with ¼", ⅜", and 1" pipe threads, with capacities of 30, 90, and 350 cubic feet per minute, respectively.

They may be bench mounted, or as an integral part of a fixture with remote controls.

## HF Voltmeter for TV, FM, and Radar

A new type, MV-18A, vacuum-tube voltmeter, which measures rf voltage down to 1 millivolt at frequencies between 1 and 200 Mc, has recently been developed by **Millivac Instruments,** P.O. Box 3027, New Haven, Conn.

In the previously mentioned range, it is flat within 10 per cent. When used for higher frequencies, larger response corrections have to be made. Range is 10 microvolts to 2,500 Mc.

For low-voltage measurements, the MV-18A uses germanium "pseudo-thermocuples" as a detector, and a carrier type dc amplifier which converts the dc voltages, into meter readings. Up to 1,000 volts, regular crystal diode rectification is used.

Direct TV and FM field-strength measurements, complete hf signal tracing through TV and FM receivers, at actual operating signal levels, and vhf and uhf laboratory research are applications of this new instrument.

## New AF Bridge

The new Model 100 Bridger, an instrument for bridging a vacuum-tube voltmeter, distortion meter, and/or oscilloscope across any part of an af circuit through a shielded cable with none of the load of the meters or the cable on the circuit, is being marketed by **Audio Instrument Co.,** 1947 Broadway, New York 23, N. Y.

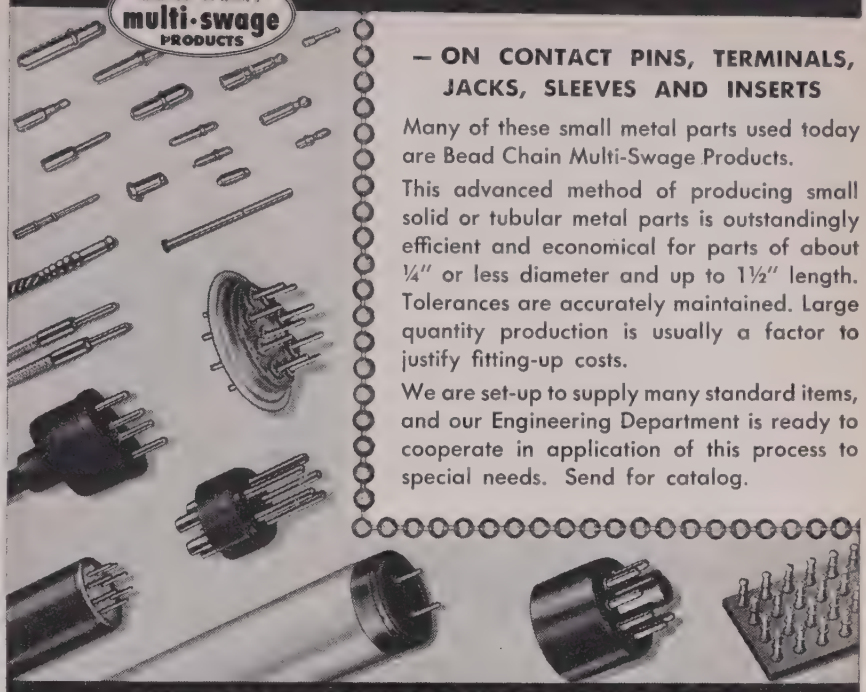
The Model 100 has an input impedance of 100 megohms in parallel with 6 $\mu\mu$f when using 3' shielded input. The output is 200 ohms with one side grounded.

Voltage ratio: output/input is 0.98 (−0.2db) up to 30 volts with a low-capacity circuit, and up to 25 volts with regular shielded cable. This may be ex-

*(Continued on page 55A)*


**To Lower Your Production Costs**

BEAD CHAIN multi-swage PRODUCTS



**— ON CONTACT PINS, TERMINALS, JACKS, SLEEVES AND INSERTS**

Many of these small metal parts used today are Bead Chain Multi-Swage Products.

This advanced method of producing small solid or tubular metal parts is outstandingly efficient and economical for parts of about ¼" or less diameter and up to 1½" length. Tolerances are accurately maintained. Large quantity production is usually a factor to justify fitting-up costs.

We are set-up to supply many standard items, and our Engineering Department is ready to cooperate in application of this process to special needs. Send for catalog.

**THE BEAD CHAIN MANUFACTURING CO.**
**60 Mountain Grove St., Bridgeport, Conn.**

**NEW T. V. IDEAS**
**NEED ACME ELECTRIC TRANSFORMER *performance***

New engineering ideas, to advance the reception qualities of Television, need better than average transformer performance. Acme Electric engineers will assist your ideas by helping you design a transformer, exactly in accordance with your needs.

Acme ACME Electric
TRANSFORMERS

**ACME ELECTRIC CORPORATION**
448 Water St. Cuba, N. Y., U. S. A.

THE great majority of this country's successful men have reached their present position after many years with the same organization. Top men in major industries have generally been with their respective companies for many years before they gained the knowledge and experience necessary to equip them for their present executive duties. On the other hand, those men who change their employment every two or three years are rarely in a position to be chosen for a responsible position.

Every organization places trust in its "old-timers." The employee with ten, twenty, or more years of service has the complete confidence of both his superiors and subordinates. His familiarity with his duties is unquestioned, and his ability to complete a given task is recognized.

If you are interested in a stable career holding ample opportunity for personal advancement, and are seriously interested in the field of Vacuum Tube Research, we would like to hear from you. Send your résumé to:

DIVISIONAL PERSONNEL MANAGER

**NATIONAL UNION RESEARCH DIVISION**

350 SCOTLAND ROAD, ORANGE, NEW JERSEY

**PHYSICISTS AND ENGINEERS**

This expanding scientist-operated organization offers excellent opportunities to alert physicists and engineers who are interested in exploring new fields. We desire applicants of Project Engineer caliber with experience in the design of electronic circuits (either pulse or c. w.), computers, or precision mechanical instruments. This company specializes in research and development work. Laboratories are located in suburbs of Washington, D.C.

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**PROJECT ENGINEERS**

Real opportunities exist for Graduate Engineers with design and development experience in any of the following: Servomechanisms, radar, microwave techniques, microwave antenna design, communications equipment, electron optics, pulse transformers, fractional h.p. motors.

SEND COMPLETE RESUME TO EMPLOYMENT OFFICE.

**SPERRY GYROSCOPE CO.**

DIVISION OF THE SPERRY CORP.

GREAT NECK, LONG ISLAND

## POSITIONS OPEN

The following positions of interest to I.R.E. members have been reported as open. Apply in writing, addressing reply to company mentioned or to Box No. ....

**The Institute reserves the right to refuse any announcement without giving a reason for the refusal.**

### PROCEEDINGS of the I.R.E.

1 East 79th St., New York 21, N.Y.

#### RADIO ENGINEERS

Outstanding opportunity with progressive, rapidly growing company for radio engineers experienced in high frequency work. An interesting, attractive future assured, but requirements of jobs must be paralleled by necessary skill. If you have a background of high frequency work, tell us about yourself in résumé giving education, experience and salary requirements. Plant located in New Jersey within commuting distance of New York City. Box 569.

#### ELECTRONICS TEACHER

Electronics teacher to take charge of electronics option at accredited state land grant college in northwest. Salary to $4800.00 for nine months. Write giving picture, education, experience, references and complete personal data to Box 572.

#### ELECTRICAL ENGINEER - PHYSICIST

Graduate electrical engineer or physicist experienced in microwaves and servomechanism for design and layout of electronic circuits. Write Chance Vought Aircraft, Division United Aircraft Corp., Box 5907, Dallas, Texas.

#### INSTRUCTOR

There will be an opening in September for an instructor to teach electronics, transmission line and wave guide theory. Salary depends on qualifications and is up to $5600.00 for nine months. Possibility of later appointment at lower rank and salary. Box 573.

#### ENGINEER

Large active midwestern quartz crystal plant needs first class quartz crystal engineer, well grounded in theory and with complete experience in manufacturing and testing procedures all types quartz units. Send complete detailed information on experience and background in first reply. Salary open. Our employees know of this ad. Box 574.

#### TECHNICAL WRITER

An opportunity for an experienced technical writer. Preferably an electrical engineering graduate with experience in the field of electronic development. Research laboratory located adjacent to Washington, D.C. Salary commensurate with experience. Box 576.

# Positions Wanted

*(Continued from page 52A)*

inquiries from firms having need for addition to sales engineering staff or assistant to top executive. Young, energetic, widely traveled with a solid background of research design and supervision in all phases of electrical and electronic equipment. Capable of handling sales, engineering, production and personnel. Box 281 W.

### ELECTRONICS ENGINEER

Guided missile electronics engineer. Currently engaged in production engineering of guided missiles. 3 years experience in development of guidance and control equipment. 4 years radar development experience for Army. Graduate engineer with post-graduate school. Box 282 W.

### ENGINEER

Graduate of American Television Institue of Technology, May 1949 with B.S.T.E. Age 24. Single. Presently engaged in post-graduate work in the U.H.F. field. Desires laboratory work in the New York City suburban area. Box 298 W.

### ENGINEER

B.E.E., June 1949, Polytechnic Institute of Brooklyn, Tau Beta Pi, Eta Kappa Nu. Age 25. Married. 2½ years in Army Signal Corps. Desires position in development or product engineering. Prefer New York location but will consider work anywhere in United States. Box 299 W.

### TECHNICAL WRITER

Development engineer available for writing assignments in radio, television, and allied arts. Technical articles, instruction booklets and similar work treated with strictest confidence on commission basis. Box 300 W.

### FIELD ENGINEER

Currently engaged U.S.N. field engineering. For past 9 years have been supervising crews for installation and maintenance of Naval Radar, Sonar, V.H.F., H.F., and communication equipment (receivers and transmitters). Graduate of Naval Matériel School, Washington, D.C., B.S. in Applied Electronics, St. Louis University. Age 30. Married, 3 children. Available June 30, 1949. Box 301 W.

### ELECTRONICS ENGINEER

B.S. in Radio Engineering, and graduate work in Electrical Engineering. Former communications and fighter control officer. Desires research in electronics or electrical engineering. Married, 1 child. Location immaterial. Box 302 W.

### ENGINEER MANAGER

Harvard M.S. in communication engineering. Directed important and extensive wartime Loran project in Pacific. Recently Development Division Engineering Manager. Desires permanent and responsible position with progressive organization. Box 303 W.

### RADIO ENGINEER

Radio Engineer, 24, single, Inter. B.Sc., 3 years experience in electronic research and development, left England July, seeks position in electronic laboratory of American university with view of continuing study. Box 304 W.

### RADIO ENGINEER

B.S. in radio engineering, one course to complete for B.S.E.E. Married, no children. Age 26. 2½ years experience telephone carrier and VHF installation

*(Continued on page 54A)*


*Positions Available for*

**ELECTRONIC ENGINEERS**

with

**Development & Design Experience**

in

**MAGNETIC TAPE RECORDING**

**MICROWAVE COMMUNICATIONS**

**SONAR EQUIPMENTS**

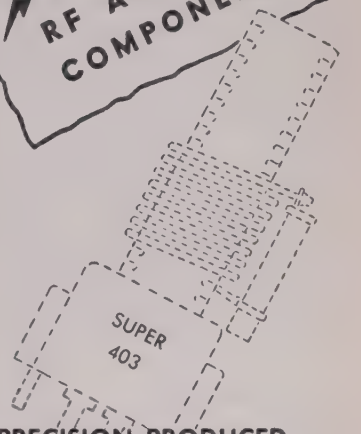
**Opportunity For Advancement Limited Only By Individual Ability**

**Send complete résumé to:**
**Personnel Department**

**MELPAR, INC.**
**452 Swann Avenue**
**Alexandria, Virginia**

**NOTE THIS NAME**

SUPER RF AUDIO TV COMPONENTS




● PRECISION PRODUCED
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**SUPER ELECTRIC PRODUCTS CORP.**
*Pacing Electronic Progress With Ingenuity*
**1057 Summit Ave., Jersey City 7, N. J.**

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**CAPITOL RADIO ENGINEERING INSTITUTE**

*An Accredited Technical Institute*

ADVANCED HOME STUDY AND RESIDENCE COURSES IN PRACTICAL RADIO-ELECTRONICS AND TELEVISION ENGINEERING

Request your free home study or residence school catalog by writing to:

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WASHINGTON 10, D.C.

*Approved for Veteran Training*

**Radio and Radar Development and Design Engineers**

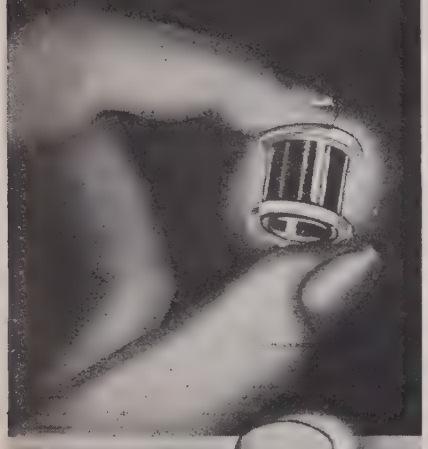
***Openings for experienced men at***

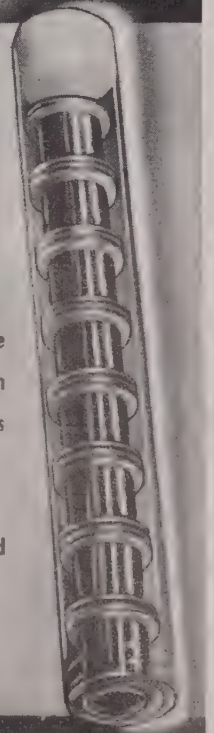
**HAZELTINE ELECTRONICS CORPORATION**
**Little Neck, L.I., N.Y.**

Please furnish complete resume of experience with salary expected to:
Director of Engineering Personnel

**(All inquiries treated confidentially)**

Etched
TUNGSTEN
WIRE
• From .0004" to .00015" diameter and even smaller





• Accurate
• Uniform
• Smooth

Also available in Molybdenum and other metals

•

Write for Details and List of Products

SIGMUND COHN CORP.
44 GOLD ST. NEW YORK
SINCE 1901

# Positions Wanted

(Continued from page 53A)

and maintenance. Desires research or design position anywhere in United States. Box 305 W.

### TELEVISION ENGINEER

Graduate American Television Institute of Technology May 1949 with B.S.T.E. Age 35, married, 1st class F.C.C. license 5 years electrical maintenance, 3 years radar maintenance, 3 years radio servicing. Desires positions as TV station engineer. Prefer east or mid-west. Box 306 W.

### ELECTRONICS ENGINEER

B.S. physics. Age 27. Married, no children. 2 years industrial electronics research and development. Some guided missile development. 3 years Army Radar developing and maintainance. Anywhere in United States, will also consider foreign position. Box 307 W.

### ELECTRONICS DESIGN ENGINEER-ELECTRONICS INSTRUCTOR

B.Sc. 1937 University of Chicago. Age 32. Married. 3 years experience in design of radar equipment with eastern manufacturer. 2½ years experience in Navy as radar maintenance officer. Have had teaching experience in physics. Desires position as electronic design engineer in midwest, or electronics instructor in midwestern college. Box 308 W.

### ENGINEER

B.E.E. 1948 electronics option Georgia School of Technology. Age 22. 1½ years electronic technician U. S. Navy. 1st class radio telephone F.C.C. license. 1 year industrial experience in design and development of radar components. Member Eta Kappa Nu and Tau Beta Pi. Desires work in development. Box 309 W.

### ELECTRONIC ENGINEER

B.S. in E.E., with high distinction, University of Connecticut, June 1949. Experience: 1 year teaching, 4 years electronic technician. Age 28. Research or development position desired. M. Cannizzaro, 22 Division St., Waterbury, Conn.

### JUNIOR ENGINEER OR TECHNICAL WRITER

B.S.E.E. June 1949 Illinois Institute of Technology. Single, age 23. Desires position in sales engineering or production in in United States. Willing to travel. 1½ years experience as Navy electronic technician, power plant operator, and electronic inspector. Excellent references. Box 310 W.

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

## Recent Catalogs

• • • The May issue of the *Research Worker* describes three popular types of power supplied for cathode-ray tube high voltage. This paper is printed by **Aerovox Corp.**, New Bedford, Mass., from whom a subscription may be obtained by application.

ANNOUNCING A NEW 8" SPEAKER WITH A NEW HARD-HITTING RANGE

JIM LANSING SIGNATURE
8" SPEAKER
100 TO 12,000 C. P. S.

WHERE QUALITY REPRODUCTION IS A "MUST" and space is at a premium—the Jim Lansing 8" Speaker answers the problem! High efficiency and good over-all performance. For improved radio, phonograph and custom television sound reproduction. Designed especially for commercial or industrial use. Ideal for music distribution and paging systems. At all better dealers and distributors.

MODEL D-1002
Two-Way System

For FM monitoring and high quality home sound reproduction. Console type cabinet.

*See your Jobber or write to:*

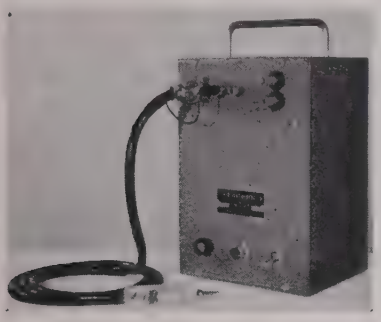
JAMES B. LANSING SOUND INC.
2439 Fletcher Drive
Los Angeles, California

# News—New Products

**These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.**

*(Continued from page 49A)*

tended to 250 volts by adding Model 104 voltage divider, which has a 10 to 1 ratio.



The cable capacity is almost balanced out by the circuit configuration, and although the capacity is low, the cable retains flexibility.

## Super Midget Relay

A new low-cost super mdiget relay, Model SM, in which the magnetic circuit elements all perform multiple functions, permitting an appreciable reduction in size without loss of operating efficiency, has been designed and manufactured by **Potter & Brumfield Sales Co.**, 549 W. Washington Blvd., Chicago 6, Ill.

Dimensions of the open SM are $\frac{5}{8}$" diameter, by $1\frac{5}{16}$" over-all length. Windings available up to 3,400 ohms, permitting operation up to 75 volts dc with minimum sensitivity of 5 ma at 80 milliwatts. Maximum coil dissipation is 1.75 watts at 83°C rise. Contacts are silver, and rated at 2.5 amperes for 100 operations, 1 ampere for 50,000, or 0.25 amperes for continuous operation on 115 volt 60 cps noninductive load.

In variance to the open type, the SM is available dust sealed in polystyrene 5-pin plug-in enclosure, or hermetically sealed in glass with a miniature 7-pin tube base. The latter can be evacuated and gas filled if desired.

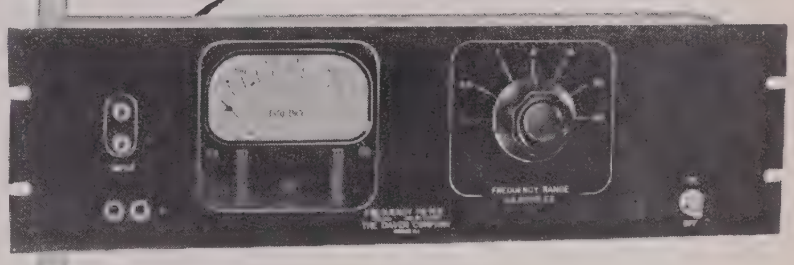
*(Continued on page 57A)*


*Now . . .*

**DAVEN Electronic Frequency Meter**

**Measures**

**20 C Y to 100 K C**



The Type 838 Frequency Meter is a direct reading instrument designed to measure audio and supersonic frequencies from 20 to 100,000 cycles per second. The instrument has great laboratory and industrial utility in applications requiring either occasional or continuous frequency measurement in the above spectrum. A jack connection has been provided on the back of the instrument for the use of an external recording milliammeter for applications where a continuous graphic frequency record is required.

*— Features —*

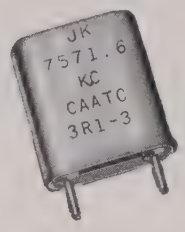
- Frequency range from 20 cycles to 100 KC.
- Seven ranges available with an accuracy of 2% of full scale on all ranges.
- Can operate on input voltage as low as ½ volt.
- Large easy-to-read meter with illuminated dial.
- Built-in voltage regulated power supply.
- Indication on meter is substantially independent of input wave form.
- May be used with an Esterline-Angus ink recorder to make permanent records of frequency runs.
- Mounted on standard 5¼" relay rack panel.

*Write for additional information*
*Dept. IE-8*

THE DAVEN CO.
191 CENTRAL AVENUE
NEWARK 4, NEW JERSEY

# Crystals for the Critical

## JK "AIRLIFT" SAVES DAY FOR AIRLINE




A commercial airline urgently needed transmitter crystals so that their flight schedules would not be upset.

Quick delivery of these crystals was made to the municipal airport the next morning by the James Knights Co. plane. Thanks to the speedy delivery, the airline plane was able to take off on its scheduled flight.

James Knights Co. engineers have complete correlation data for most airline equipment, and can meet correct specifications to fulfill your needs.

In emergencies, you can count upon receiving the same spectacular service as the airline described above.

The James Knights Co. can furnish stabilized crystals to meet every ordinary—or special—need.

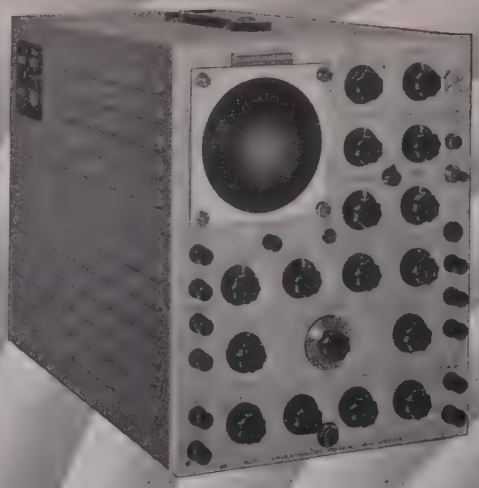
*New James Knights Catalog On Request*

**The JAMES KNIGHTS Co.**

SANDWICH, ILLINOIS

JK





TEKTRONIX TYPE 511-AD OSCILLOSCOPE

$845.00 f.o.b. Portland, Ore.

## TRANSIENT PHENOMENA

*Does your research problem include the necessity for observation of steep fronted pulses, non-recurrent or non-sinusoidal wave shapes?*

*The* ***Tektronix Type 511-AD Oscilloscope*** *has been designed specifically for coping with the above requirement.*

*Video Band Pass — 5 Cycles, 10 Megacycles.*
*Amplifier Rise Time, .05 Microsecond.*
*Video Signal Delay Network, 0.25 Microsecond*
*Cont. Var. Triggered Sweeps, .1 Sec., 1, Microsec.*
*All DC Regulated Against Line Voltage Changes*
*Self Contained — Total Weight 50 Pounds.*
*Unusually Low Cost.*

*Engineering sales representation in principal areas.*

TEKTRONIX INC.

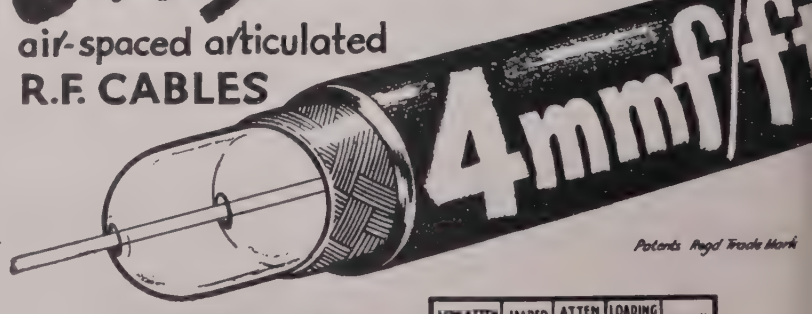
Cables: Tektronix **TEXTRONIX, INC.** 712 S. E. Hawthorne Blvd. Portland 14, Oregon



# Only with CO-AX

air-spaced articulated R.F. CABLES

4 mmf/ft



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| LOW ATTEN TYPES | IMPED OHMS | ATTEN db/100ft at 100 Mc/s. | LOADING K.w | O.D." |
|---|---|---|---|---|
| A 1 | 74 | 1.7 | 0.11 | 0.36 |
| A 2 | 74 | 1.3 | 0.24 | 0.44 |
| A 34 | 73 | 0.6 | 1.5 | 0.88 |

HIGH P... FLEXI...

| LOW CAPAC TYPES | CAPAC mmf/ft. | IMPED OHMS | ATTEN db/100ft 400 Mc/s. | O.D." |
|---|---|---|---|---|
| C 1 | 7.3 | 150 | 2.5 | 0.36 |
| PC 1 | 10.2 | 132 | 3.1 | 0.36 |
| C 11 | 6.3 | 173 | 3.2 | 0.36 |
| C 2 | 6.3 | 171 | 2.15 | 0.44 |
| C 22 | 5.5 | 184 | 2.8 | 0.44 |
| C 3 | 5.4 | 197 | 1.9 | 0.64 |
| C 33 | 4.8 | 220 | 2.4 | 0.64 |
| C 44 | 4.1 | 252 | 2.1 | 1.03 |

PHOTO... CAB...

V.L.C...

★ *Very Low Capacitance cable*

**TRANSRADIO LTD**
CONTRACTORS TO H.M. GOVERNMENT
138A CROMWELL ROAD · LONDON SW7 ENGLAND
CABLES: TRANSRAD LONDON

**MEASUREMENTS CORPORATION**
***Model 59***

2.2 mc. to 400 mc.

# MEGACYCLE METER

Radio's newest, multi-purpose instrument consisting of a grid-dip oscillator connected to its power supply by a flexible cord.

***Check these applications:***

- **For determining the resonant frequency of tuned circuits, antennas, transmission lines, by-pass condensers, chokes, coils.**
- **For measuring capacitance, inductance, Q, mutual inductance.**
- **For preliminary tracking and alignment of receivers.**
- **As an auxiliary signal generator; modulated or unmodulated.**
- **For antenna tuning and transmitter neutralizing, power off.**
- **For locating parasitic circuits and spurious resonances.**
- **As a low sensitivity receiver for signal tracing.**

**MANUFACTURERS OF**
Standard Signal Generators
Pulse Generators
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Vacuum Tube Voltmeters
UHF Radio Noise & Field Strength Meters
Capacity Bridges
Megohm Meters
Phase Sequence Indicators
Television and FM Test Equipment

*SPECIFICATIONS:*

Power Unit: 5⅛" wide; 6⅛" high; 7½" deep. Oscillator Unit: 3¾" diameter; 2" deep.

**FREQUENCY:**
2.2 mc. to 400 mc.; seven plug-in coils.

**MODULATION:**
CW or 120 cycles; or external.

**POWER SUPPLY:**
110-120 volts, 50-60 cycles; 20 watts.

**MEASUREMENTS CORPORATION**
**BOONTON NEW JERSEY**


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 55A)*

## Decade Resistance Box

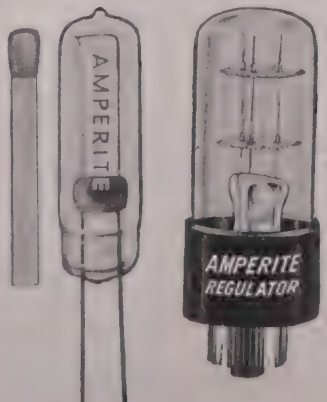
A new Model 10 decade power resistance box, suitable for laboratory and test applications, has been developed by **Marma Electronic Co.,** 1632-36 N. Halstead St., Chicago 14, Ill. (a new division of Fidelity Amplifier Co. of the same address).

The manufacturer states that the combination of power handling capacity, 2 per cent accuracy, and wide range afforded by a four-decade box makes it practical for replacing the accurate ½ per cent type used as standards, as these cannot be subjugated to any appreciable load without damage.

This box will dissipate a minimum of 10 watts, and maximum of 30 watts, depending on setting. Four decades allow for flexibility and provide for a total available resistance of 99,000 ohms. Low inductance lends accuracy of readings on all af and the lower rf. The case is metal and may be grounded, providing additional shielding when necessary.

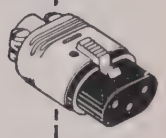
## Two New Ballast Tubes

A subminiature for minute applications, and an aircraft ballast tube to withstand the vibrations of airborne radio equipment, have been developed by **Amperite Co., Inc.,** 561 Broadway, New York 12, N. Y.

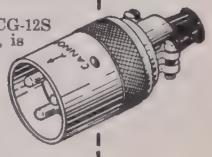



*(Continued on page 59A)*

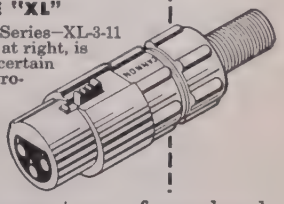
**TYPE "O"**
Type "O" Series—shown at right is the 03-11 Plug, with three 30-amp. contacts, fits certain quality types, notably Western Electric.



**TYPE "P"**
Type "P" Series—P3-CG-12S Plug shown at right, is standard with most broadcast stations and used with RCA and other equipment. . . 7 interchangeable inserts.



**TYPE "XL"**
Type "XL" Series—XL-3-11 Plug shown at right, is standard on certain RCA, Electro-Voice and Turner microphones. Two inserts: XL-3, XL-4.



Used on many types of sound and communication equipment in addition to microphone, *Cannon Plugs* are recognized by engineers, sound men and hams as the quality fittings in the field. Over a period of years various improvements have been made in insulating materials, shell design, material and clamp construction.

Available through many parts jobbers in the U.S.A. . . In *Louisville:* Peerless Electronic Equipment Co. In *Flint:* Shand Radio Specialties. In *Syracuse:* Morris Dist. Co. In *Toledo:* Warren Radio. In *Norfolk:* Radio Supply Co.

*Bulletin PO-248 covers all the engineering data on the above 3 series; RJC-2 the prices; CED-8 Sheet lists jobbers. For copies address Department H-3-7*

SINCE 1915
**CANNON ELECTRIC**
*Development Company*
**3209 HUMBOLDT ST., LOS ANGELES 31, CALIF.**
IN CANADA—CANNON ELECTRIC CO., LTD.

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## "NOBLELOY" METAL FILM PRECISION RESISTORS

★ GENUINE METAL FILM
★ NOT CARBON
★ NOTHING TO BURN
★ CLOSE TOLERANCES ½%, 1%
★ REASONABLE PRICES

The "NOBLELOY" X Type Resistors has proven itself over a period of 5 years in thousands of critical electronic circuits. Values and tolerances, ½ ohm to 30 megohms 1%; ½ ohm to 200,000 ohms, ½%. Sizes, ½ to 5 watt.

**CONTINENTAL CARBON, INC.** CLEVELAND 11, OHIO



# AIRBORNE RADIO
FOR ALL CLASSES OF AIRCRAFT

by

*Aircraft Radio Corporation*

*Equipment for:*

- TWO-WAY VHF
- STANDARD LF RANGES (with homing loop)
- VHF OMNI RANGES
- LOCALIZERS
- GCA VOICE
- ISOLATION AMPLIFIERS (10 inputs—2 outputs)

Name of nearest sales and installation agency on request

ARC

**Aircraft Radio Corporation**
BOONTON, NEW JERSEY



# "Wow-Meter"

Newly developed direct-reading instrument simplifies measurements of wow and flutter in speed of phonograph turntables, wire recorders, motion picture projectors and similar recording or reproducing mechanisms. It is the only meter in existence giving direct steady indication of meter pointer on scale.

The Furst Model 115-R "Wow-Meter" is suitable for both laboratory and production application and eliminates complex test set-ups.

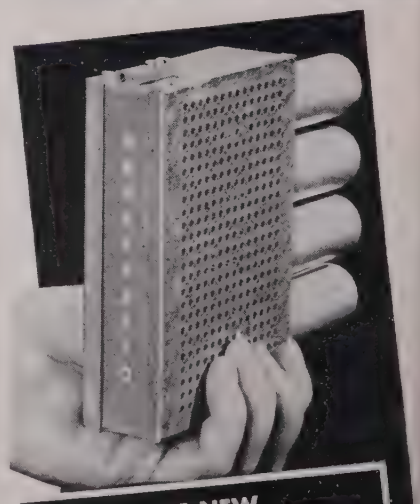
A switch on the front of the panel permits selection of low frequency cut-off and corresponding meter damping for use on slow speed turntables.

*Frequency Response: ½ to 120 cycles or 10 to 120 cycles*

*Inquiries Invited on our line of Regulated Power Supplies*

**FURST ELECTRONICS**
14 S. Jefferson St., Chicago 6, Ill.





THE NEW
**BERKELEY**
MODEL 700
**DECIMAL COUNTING UNIT**

This unique packaged component is *easily built into* your apparatus. It has *true decimal reading*, and simple binary circuit with reliable *automatic interpolation*. Miniature size. Moderate price. Immediate shipment.

*Send for Bulletin DCU-116*

*Berkeley Scientific Company*
SIXTH AND NEVIN AVE • RICHMOND, CALIFORNIA

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

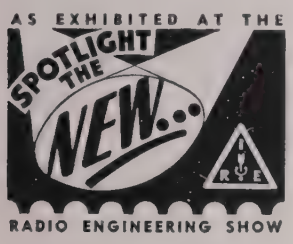
*(Continued from page 57A)*

On the right is the subminiature. This tube was designed without prongs, eliminating the necessity of a base. The leads are soldered directly to the leads from the tube.

This tube can be supplied to dissipate any wattage up to 3 watts. Maximum current 0.9 amperes. A 100 per cent increase in voltage will produce a change of less than 5 per cent. An ambient change of −50°C to +70°C will cause a difference in current of less than 2 per cent.

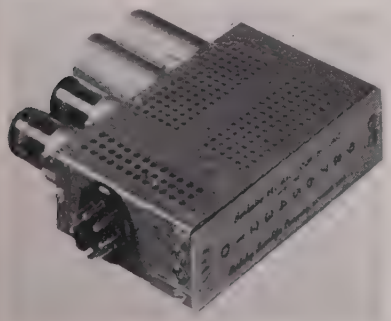
On the left is the aircraft type, which will withstand 40 g, and reacts identically to temperature extremes as the tube described above.

This tube can be supplied to dissipate up to 25 watts, from 60 ma to 3 amperes.




## Electronic Decimal Counting Unit

For use in industrial and commercial applications, the Model 700 Decimal Counting Unit was recently marketed by **Berkeley Scientific Co.**, 6th St. & Neven Ave., Richmond, Calif.

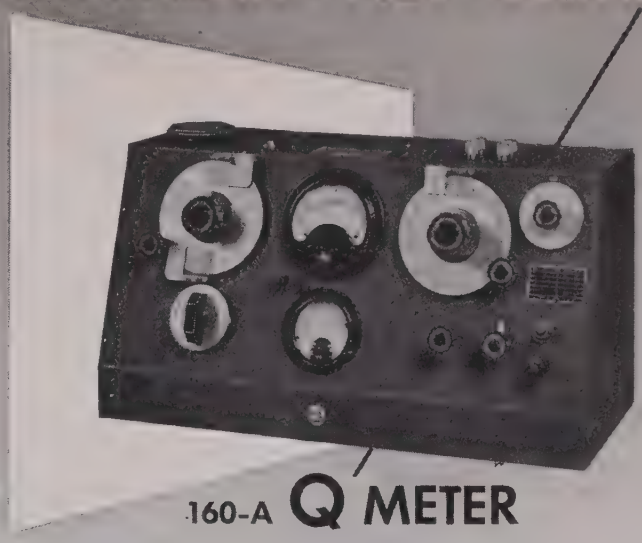


To be used primarily in counting, timing, and frequency measurement work, the Model 700 is a four-tube plug-in unit with a scale-of-ten counting circuit capable of rates in excess of 40,000 pulses per second, and of resolving pulse pairs spaced less than 5 microseconds apart.

Counts are read from 10 neon lamps on the panel numbered 0 to 9. Each count is indicated directly by illuminating the lamp corresponding to the pulses received. Units may be cascaded to count any number. Thus, by mounting several next to each other, counts may be read directly.

*(Continued on page 60A)*

MEASUREMENT • TEST • CONTROL



160-A Q METER

The 160-A Q-Meter is unexcelled for laboratory and development applications, having received world wide recognition as the outstanding instrument for measuring Q, inductance, and capacitance at radio frequencies.

Frequency Range: 50 kc. to 75 mc. (8 ranges)
Q Measurement Range: 20 to 250 (20 to 625 with multiplier)
Range of Main Q Capacitor: 30-450 mmf.
Range of Vernier Q Capacitor: +3 mmf., zero, −3 mmf.

*For further specifications and descriptive details, write for Catalog F*

BOONTON RADIO Corporation
BOONTON, N. J., U.S.A.

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50 MC WIDEBAND VIDEO OSCILLOSCOPE FTL-32A

- Vertical amplifier bandwidth of 10 cps to 50 mc.
- High deflection sensitivity over the entire bandwith.
- Low-capacity probe maintaining high sensitivity.
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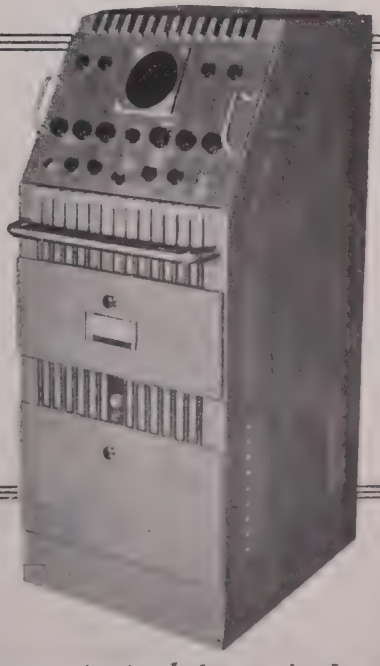

*Write for complete FTL-32A brochure.*

Federal Telecommunication Laboratories, Inc.
*An I.T.&T. Associate*
500 Washington Avenue
Nutley 10, N.J.

# S·S·White MOLDED RESISTORS

The "All-Weather" Resistors

## ARE USED IN THIS ULTRA SENSITIVE ELECTRONIC PHOTOMETER

**In this instrument—designed for measurement of very low light values—S.S.White Resistors serve as the grid resistance in the all-important high-gain D.C. amplifier circuit. The manufacturer, Photovolt Corp., New York, N.Y., reports that the resistors "work very satisfactorily"—which checks with the experience of the many other electronic equipment manufacturers who use S.S.White resistors.**

**S.S.WHITE RESISTORS**

are of particular interest to all who need resistors with inherent *low noise level* and *good stability* in all climates.

HIGH VALUE RANGE
10 to 10,000,000 MEGOHMS
STANDARD RANGE
1000 OHMS to 9 MEGOHMS

**WRITE FOR BULLETIN 4505**

**It gives essential data about S.S.White Resistors, including construction, characteristics, dimensions, etc. Copy with price list on request.**

*Photo courtesy of Photovolt Corp., New York, N.Y.*

**S.S.WHITE INDUSTRIAL DIVISION**
THE S. S. WHITE DENTAL MFG. CO.
DEPT. GR, 10 EAST 40th ST., NEW YORK 16, N. Y.

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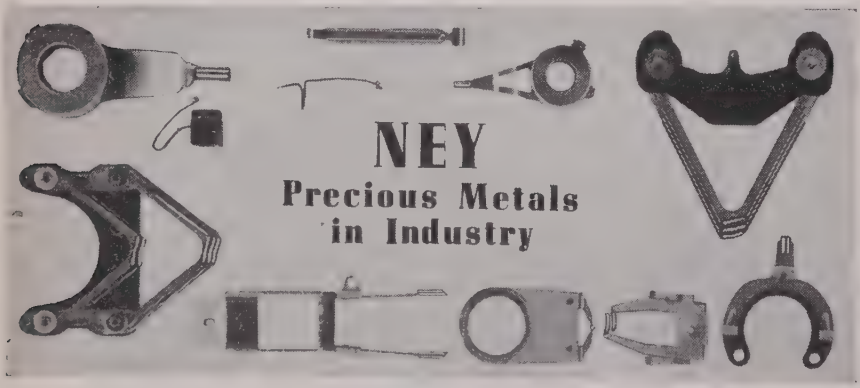
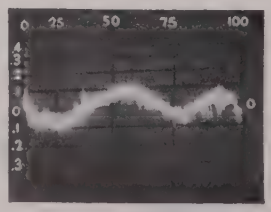
MOLDED PLASTICS PRODUCTS—MOLDED RESISTORS




## GREATLY IMPROVED LINEARITY WITH PALINEY #7* BRUSH CONTACTS

Results of life tests on nickel-chrome wire-wound potentiometers, using contacts of PALINEY #7* in comparison with phosphor bronze, showed greatly improved linearity maintained through longer service life. If you have this or similar contact problems write or call our Research Department for detailed test data.

*Reg. T.M. of J. M. Ney Co.




Cathode Ray Oscillograph shows performance of modified potentiometer after one million cycles or two million sweeps of PALINEY #7* contact over wire. The initial error was reduced to ± .12% and this linearity was maintained throughout the test.

*Write or phone* (HARTFORD 2-4271) *our Research Department*

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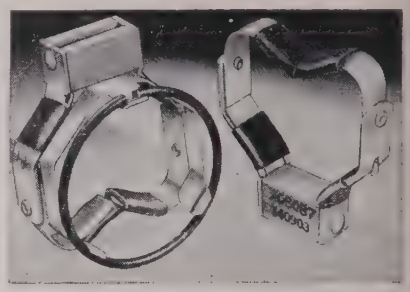
26NY49


# News—New Products

*(Continued from page 59A)*

## TV-Tube Beam Benders

Two new types of TV-tube beam benders, which serve to minimize burnt spots on screens, are announced by **Clarostat Mfg. Co., Inc.** Washington St., Dover, N. H.

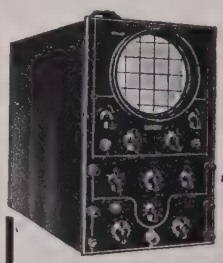


The series TV-2 has a single permanent bar magnet and is used with 10″ tubes with flux densities across the poles of 33±3G and 75±10G.

The series TV-3 is higher in cost, but features two magnets: the bar magnet for the rear and a ring magnet for the front elements. This type is used with 12″ and larger tubes, particularly those of bent-gun design.

Both types have rubber covered spring arms for friction fit on 1⅜″ to 1½″ necks.

*(Continued on page 61A)*

**The combined features of the popular Du Mont Type 208-B have given it a greater volume of sales than any other cathode-ray oscillograph in the world.**

# The Oscillograph that Outsells them all!

***Versatile* . . .**
Type 208-B is a general-purpose cathode-ray oscillograph, designed for both laboratory and industrial applications. Used extensively for receiver-test, strain-gage, pressure-measurement problems, and innumerable other applications.

***Sensitive* . . .**
Highest gain Y-axis amplifiers in any commercial oscillograph in its price range. Sensitivity, 10 millivolts rms per inch. Excellent low-frequency response. Recurrent sweep from 2 cps to 50,000 cps.

***Time-tested* . . .**
For many successful years, the Du Mont Type 208-B has been the leader in its field. Improvements resulting from extensive field experience have been incorporated into its design.

***Moderately priced* . . .**
The many applications of this instrument mean that it must meet varying budgets. Its low price and portability complete the requirements for an outstanding general-purpose oscillograph.

**Instrument Division**
**ALLEN B. DU MONT LABS., INC.**
**1000 Main Ave., Clifton, N.J.**

DUMONT

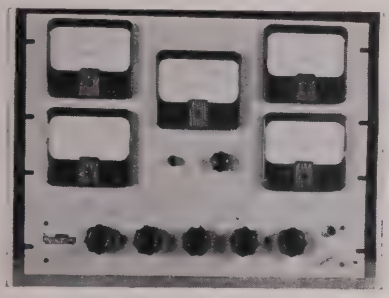
# News—New Products

**These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.**

*(Continued from page 60A)*

## New Phase Relation Meter

A new Model 108-C Phase Meter, which provides a means for measuring the phase relations existing in directional antenna systems, has been designed and developed by **Clarke Instrument Corp.**, 910 King St., Silver Spring, Md.

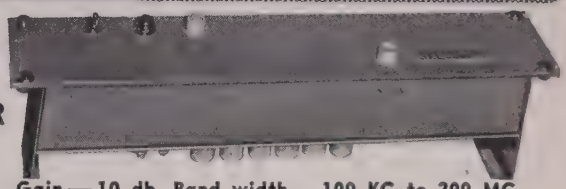


With the Model 108-C, provision has also been made for remote monitoring of amplitudes of the currents in the several elements of the array. The phase indication is marked in 2° intervals, however, ½° increments can readily be resolved.

Although intended for operation in the standard band, this meter can be supplied in other frequency ranges.

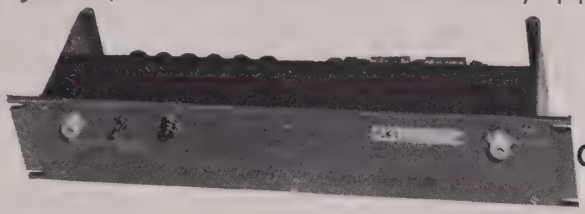

**SKL 200 MC BAND WIDTH AMPLIFIERS**

MODEL 200A
WIDE BAND
CHAIN AMPLIFIER



**Impedance — 200 ohms. Gain — 10 db. Band width — 100 KC to 200 MC. Response — ± 1 db. Standing Wave Ratio — Less than 1 db.**

Using a chain of six 6AK5 tubes the single stage Model 200A uses delay line coupling in the grid and plate circuits. Due to its low impedance existing coaxial cables can be used. Due to its wide band width it is invaluable as an aperiodic preamplifier for signal generators, sweep generators, vacuum tube voltmeters and other laboratory equipment.



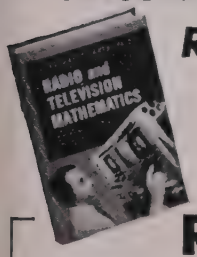
MODEL 202
WIDE BAND
CHAIN AMPLIFIER

**Band width — 100 KC to 200 MC. Gain — 20 db. Response — ± 1.5 db. Impedance — 200 ohms. Standing wave ratio — Less than 1.5 db.**

The dual stage, Model 202 has substantially linear phase shift owing to mutual inductance coupling in the delay lines. With its wide pass band and very short rise time this amplifier offers unique advantages in the study of pulse and transient wave forms in nuclear research, oscillography and television testing.

**SKL SPENCER KENNEDY LABORATORIES, INC.**
186 MASSACHUSETTS AVE., CAMBRIDGE 39, MASS.

***To be sure your calculations are RIGHT, use***

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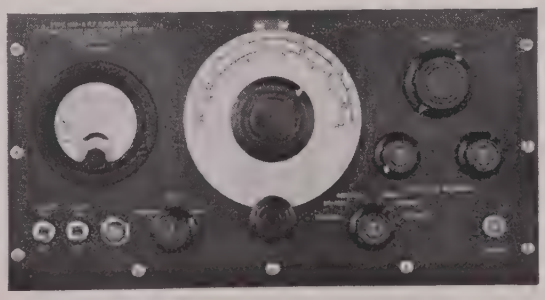
**TYPE 410A POWER R-F OSCILLATOR**



**for general laboratory use and as a signal source for R-F bridges**

NOTE THESE FEATURES

- 100 kc to 10 Mc
- High output—approximately 30 volts
- 50-60 output impedance
- Internal modulation
- Output voltmeter
- Excellent stability
- Accurate, individually-calibrated frequency scale
- Expanded frequency scale.

Write for bulletins on the type 410-A R-F Power Oscillator and other T.I.C. products—precision linear and non-linear potentiometers . . . Audio and R-F Z-Angle Meters . . . Slide Wire Resistance Boxes . . . Electronics Phase Angle Meter

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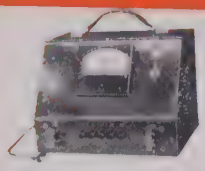
**HIGH FIDELITY OUTPUT TRANSFORMER**

High quality output transformer combines unusually wide frequency range together with very low phase shift and harmonic distortion. Frequency range ½ DB 20-30,000 cycles.



**NO. 1060 VACUUM TUBE VOLTMETER**

For use at audio, supersonic and radio frequencies. Frequency range from 10 cycles to 1.6 megacycles. Input impedance 50 megohms, input capacity 15 MMF. Voltage range of .001 to 100 volts. Frequency range from 10 cycles to 2 megacycles.

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High efficiency Auto Transformer can be used as either Step Up or Step Down transformer equipped with standard receptacle and line cord.

**NO. 1030 "Q" INDICATOR**

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**DISCRIMINATORS**

For telemetering and remote control application using audio and supersonic frequency subcarriers.

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High gain Null Detector for Bridge measurements. Contains selective circuits for 60-400-1000 cycles. Frequency range 30-20,000 cycles.

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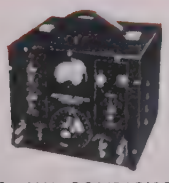
Narrow band pass filters for remote control and telemetering applications. High pass, low pass, band pass and band elimination filters for communication and carrier systems.



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For precision laboratory adjustment and incoming inspection of resistors, capacitors and inductors. Entirely self contained, A.C. operated and includes a three frequency oscillator, an A.C. bridge and a null detector.

**TOROIDAL INDUCTORS**

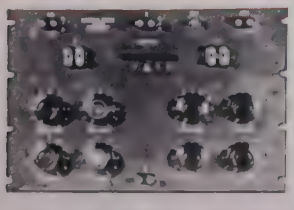
Hi Q toroidal coils wound on powdered molybdenum permalloy. Can be supplied for frequencies from 200 cycles to 200 KC Available in hermetically sealed construction potted and cased or open type units.

**NO. 1020 DIRECT READING MEGOHMETER**

Measures insulation resistances up to 2,000,000 megohms. 500 volts D.C. potential included in the instrument. Entirely self contained and A.C. operated.

**HI-Q MINIATURE TOROIDAL INDUCTORS**

Size ⅞" D. x ⅜" — weight ¾ ounce. Type TI-5 Frequency range 1000 cycles - 15,000 cycles. Type TI-7 Frequency range 10,000 cycles - 100,000 cycles. Wound on molybdenum permalloy dust cores. Available in hermetically sealed cans, potted and cased or open units.



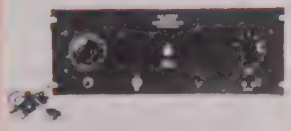
**NO. 1150 UNIVERSAL BRIDGE**

For measurement of inductors, capacitors, and determination of resistive and reactive components of impedances. Frequency range 20 cycles - 20,000 cycles. 1% accuracy.

**NO. 1210 NULL DETECTOR & VACUUM TUBE VOLTMETER**

Vacuum Tube Voltmeter: Sensitivity .1, 1, 10, 100 volts. Input impedance 50 megohms shunted by 20 mmfd. Frequency range 20 cycles - 20,000 cycles.

NULL DETECTOR: Gain 94 DB. Selective circuits for 60, 400, 1000 cycles. Frequency range 20-30,000 cycles.



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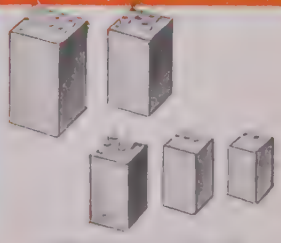
A valuable laboratory instrument with continuous variable output from .1 volt to 100 volts @ 60 cycles.



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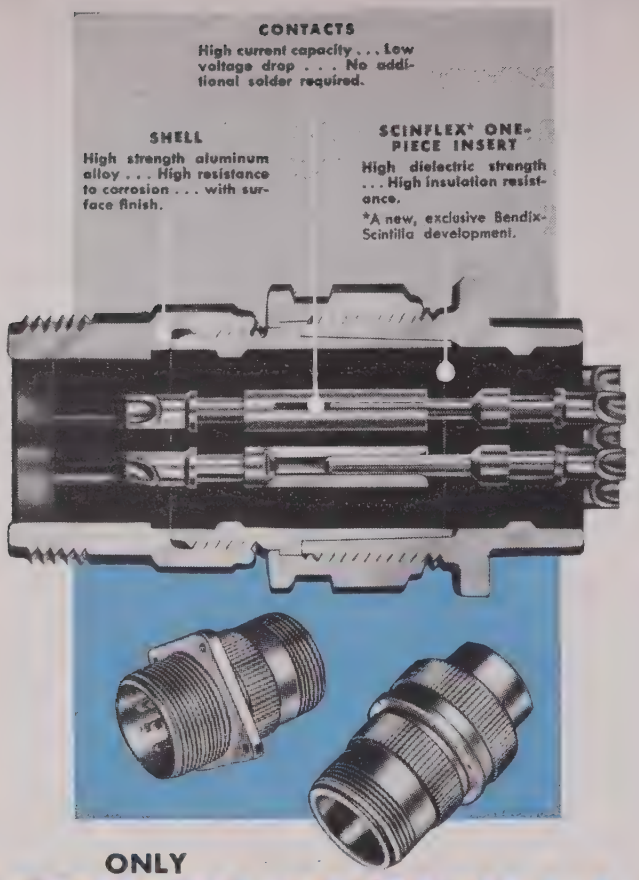


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- Moisture-proof
- Radio Quiet
- Single-piece Inserts
- Vibration-proof
- Light Weight
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector
- No additional solder required
- High Insulation Resistance

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SCINTILLA MAGNETO DIVISION of

BENDIX SCINTILLA

SIDNEY, NEW YORK

AVIATION CORPORATION

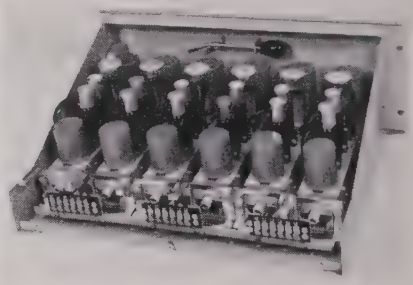
Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, New York


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

## New Plug-In Audio Amplifiers

The design of new AM, FM and Television audio amplifiers has been announced by the **Transmitter Div., General Electric Co.**, Electronics Park, Syracuse, N. Y.



The amplifiers plug into Cannon receptacles mounted at the rear of the trays. The trays fit into a shelf which can be mounted in any standard 19 inch cabinet or relay rack.

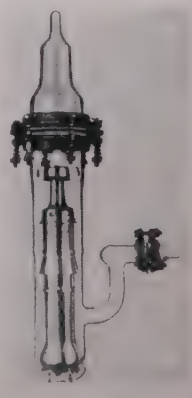
Included are the Type BA-1-C Pre-Amplifier with its' Type FA-22-A Tray, the Type BA-12-A Program/Monitor Amplifier with its' Type FA-22-B Tray, and the Type FA-23-A Shelf which will accommodate up to six of the pre-amplifiers, and up to four of the program-monitor amplifiers.

The Type BA-1-C Pre-Amplifier may be used as a microphone or transcription pre-amplifier, booster amplifier, medium-level line amplifier, or as an isolation amplifier.

The Type BA-12-A Program/Monitor Amplifier may be used as a program or line amplifier, a monitoring amplifier, or an isolation amplifier.

## New Diffusion Pump

A new oil-diffusion type vacuum pump, the HV-1, is in mass production by **Eitel-McCullough, Inc.**, 189 San Mateo Ave., San Bruno, Calif.



The HV-1 was originally designed by Eimac engineers for their own use in vacuum-tube manufacturing. It will deliver up to 67 liters per second, and has an attainable vacuum of $4 \times 10^{7}$ mm Hg.

The manufacturer states that expansion in the fields of nuclear science, research, and material processing in vacuum applications should find many applications for this pump.

*(Continued on page 26A)*

# Now

## A 100% INCREASE IN THE GL-502-A's RATED CURRENT CAPACITY AT REDUCED VOLTAGES

### 0.2 amp average with 180 v on the anode!

*"THIS COMPACT METAL THYRATRON WILL REPLACE GLASS TYPE 2050 IN YOUR CIRCUIT; YET IT'S ONLY HALF THE SIZE . . . AND SELF-SHIELDING!"*

CONTINUOUS G-E improvement in design and production makes it possible to rate the GL-502-A thyratron, for low-voltage operation, at twice its former average current capacity, or .2 amp maximum.

Here is performance sure to be welcomed by the electronic designer. No change in size is involved; the GL-502-A (only 2 1/16 inches high when seated) continues to take up minimum space. Also, the tube's self-shielding characteristic, a feature of metal-envelope types, remains an important aid in simplifying circuit and panel design.

Much electronic control equipment is being built to operate at voltages at or near low power-supply potentials. The new, higher-rated current capacity of the GL-502-A under these conditions, gives the designer "more tube to work with." Glass Type 2050—twice the size of the GL-502-A—can be replaced by the smaller thyratron with no loss in tube performance, yet with a pronounced saving in space occupied.

Investigate this great little metal thyratron *now* . . . while your new control circuit is in the planning stage! You'll save in space, gain in economy and efficiency. Get the complete story from your nearby G-E electronics office. Or wire or write *Electronics Department, General Electric Co., Schenectady 5, New York.*

**CHARACTERISTICS, TYPE GL-502-A**

| | |
|---|---|
| Max over-all height | 2⅝ inches |
| Max over-all diameter | 1 5/16 inches |
| No. of electrodes | 4 |
| Cathode voltage | 6.3 v |
| current, approx | 0.6 amp |
| heating time, typical | 10 seconds min |
| Voltage drop, typical | 8 v |
| Avg anode to control-grid capacitance | 0.2 mmfd |
| Ambient temperature limits | −55 to +90 c |

**MAXIMUM RATINGS**

| | High-voltage operation | Low-voltage operation |
|---|---|---|
| Peak anode voltage, inverse | 1,300 v | 360 v |
| forward | 650 v | 180 v |
| Anode current, instantaneous | 1 amp | 1 amp |
| average | 0.1 amp | 0.2 amp |
| Time of averaging current | 30 seconds | 30 seconds |

# GENERAL ELECTRIC

180-H29

FIRST AND GREATEST NAME IN ELECTRONICS

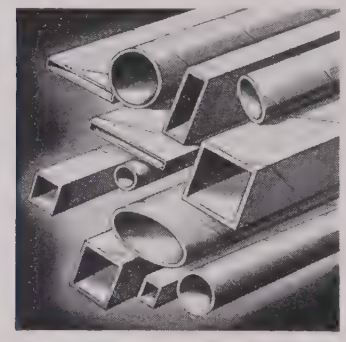
# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 22A)*

## Precision Asbestos Tubing

Originally designed by **Precision Paper Tube Co.**, 2045 W. Charleston St., Chicago 47, Ill., as a heat resistant base for coils and bobbins, this new asbestos tubing has other potentialities in the industry.



Because it is unaffected by high temperatures, this tubing could be used as insulation and as a dielectric, in such units as heaters, thermal heating devices, for insulating rods, etc.

The tube is made by spirally winding prepared asbestos tape to predetermined sizes around a mandrel, and then diformed into shape. This tubing can be supplied in any length, with wall thicknesses from 0.10 inch.

## New Power Supply

The Model B, a recently designed dc power supply that employs new type heavy duty selenium rectifiers, and has a wide range variable voltage control, and damped volt and ammeter, is now available from **Electro Products Labs., Inc.**, 549 W. Randolph St., Chicago 6, Ill.

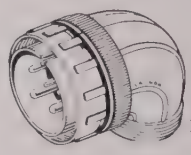
This source will deliver from 3 to 9 volts with a rating of 6 volts at 20 amperes continuous, and 35 amperes instantaneous, from 50 to 60cps 115 volt supply.

The Model B was primarily designed for testing or operating automobile radio receivers, but it will also test faulty vibrators, push button solenoids, 6-volt battery type receivers, and will provide over and under voltage operating conditions for all auto radio receivers.

*(Continued on page 30A)*


CANNON PLUGS

FOR THE RADIO TECHNICIAN

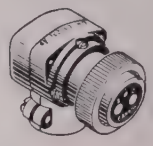


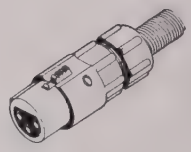
**TYPE AN**

has greatest number of inserts, variety of amperages and voltages. More than 200 layouts.

**TYPE K**

and RK similar to "AN" but an exclusive Cannon product, more rugged than type "AN". 210 inserts-layouts.





**TYPE XL**

Fast growing in popularity as the leading quality low cost microphone connector. 10 & 15 amps. contacts.

**TYPE X**

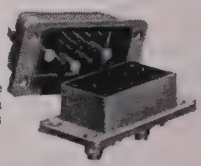
3 insert arrangements; friction type engagement. 10 and 15 amps.

**TYPE P**

Standard sound and microphone series in 7 insert arrangements. 15 & 30 amps. contacts.

**TYPE DP**

Rack & Panel type connectors with standard contacts and coaxials.



**AND 7 OTHER MAJOR TYPE SERIES.**

*Write for the new C-48 Condensed Catalog. Address Department I-377.*

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Division of Cannon Manufacturing Corp.

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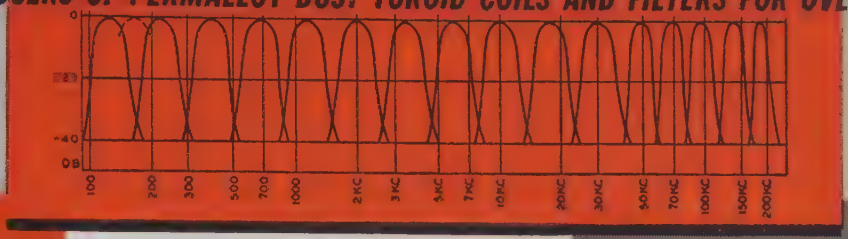
CANNON ELECTRIC CO., LTD., TORONTO 13, ONT.

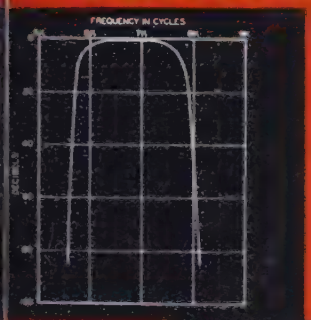
WORLD EXPORT (Excepting British Empire):
FRAZAR & HANSEN, 301 CLAY ST., SAN FRANCISCO

# FILTER SPECIALISTS

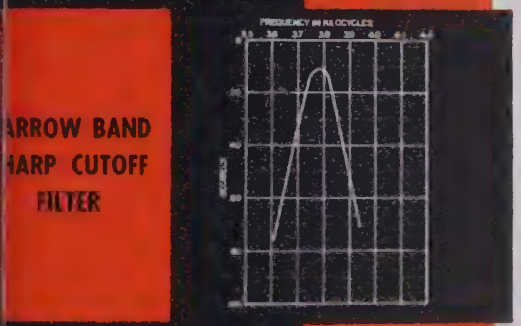
**PRODUCERS OF PERMALLOY DUST TOROID COILS AND FILTERS FOR OVER A DECADE**



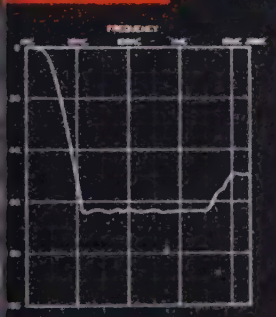

## FOR FILTERS



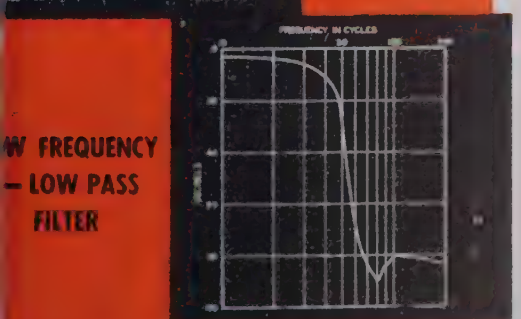

BROAD BAND SHARP CUTOFF FILTER




ARROW BAND SHARP CUTOFF FILTER



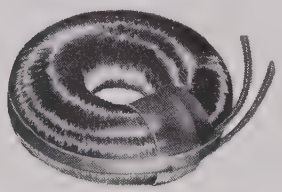
ATTENUATES 10KC TO 30 MEGACYCLES



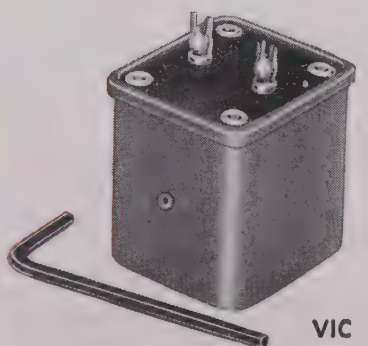

W FREQUENCY — LOW PASS FILTER

**HQA, C, D**
$1\frac{3}{16}$" Dia. x $1\frac{3}{16}$" High.

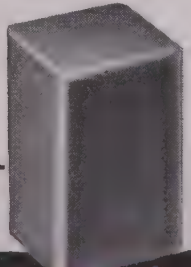
**HQB**
2⅝" L. x 1⅝" W. x 2½" H.



**UNCASED TOROIDS**



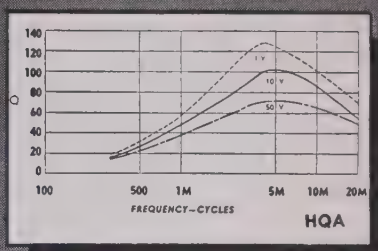
**VIC**
1⅜" L. x 1¼" W. x 1½" H.

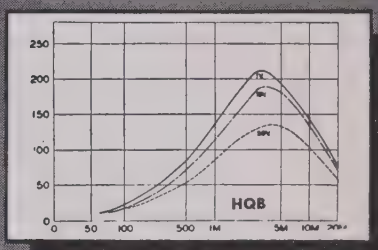


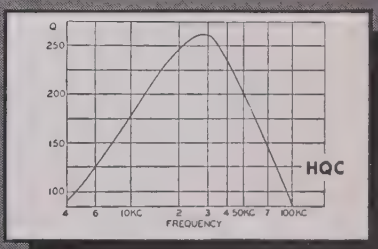
**SUB-OUNCER TOROID FILTERS**

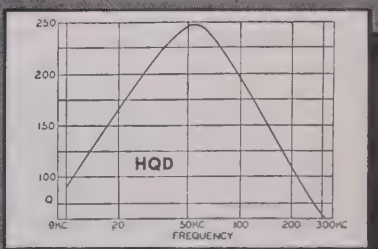
Filters employing SUB-OUNCER toroids and special condensers represent the optimum in miniaturized filter performance. The band pass filter shown weighs 6 ounces.

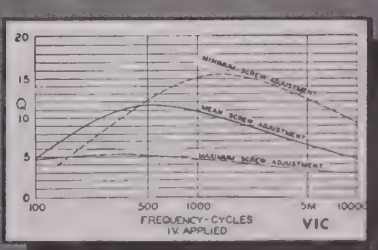
## FOR HIGH Q COILS





United Transformer Co.

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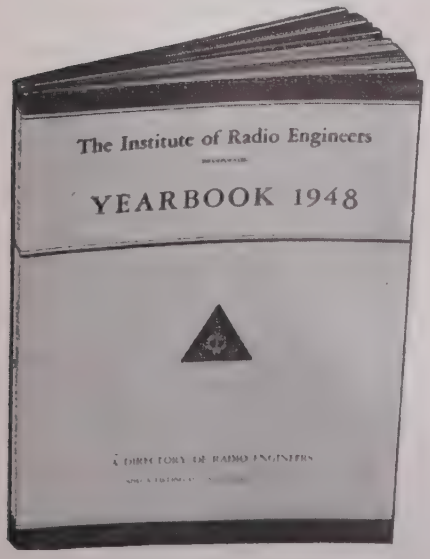
*Now You Can—*

# Find products easily!

## Look in the IRE Yearbook—

### 3347 Electronic Supply Firms Listed:

Every Firm in the alphabetical directory has address and complete line of products of interest to radio engineers is given in code numbers so you can understand what related products the firm supplies. This kind of listing gives you the most comprehensive and up-to-date picture of the company you are looking up, both as to manufactured products, and services. A cross-index provides direct reference to the page on which advertisers provide fuller information. Easy-reading type and spacing!




### Index of 75 Products and Services

This year, complete for companies who answered our requests, The Product Index shows ALL firms. Advertisers are given with complete addresses. A turn to alphabetical directory gives full data on the briefer listings.

Complete
Fast Reference
Understandable

•

Published for IRE Members
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by
THE INSTITUTE OF RADIO ENGINEERS

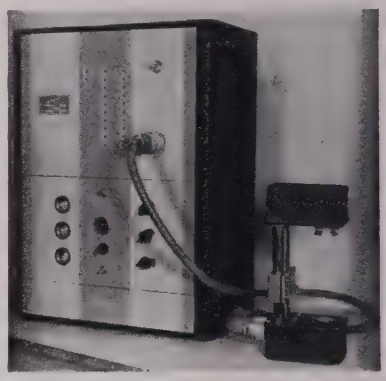

# News—New Products

**These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.**

*(Continued from page 26A)*

## New Pre-Set Type Industrial Counter

A new series of presettable high-speed electronic counters for industrial applications, with counting rates of 10,000 per minute, and operating from photoelectric or magnetic pickup sources, may be purchased from the manufacturer **Airlectron, Inc.**, P.O. Box 151, Caldwell, N. J.



Various models are designed for pre-set ranges of from 1 to 999 gross with decade selection and direct reading count indication (shown in illustration); fixed preselection of any four quantities; and for decade selection of any number up to 10,000.

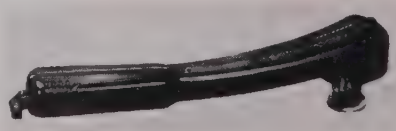
The output circuits of these counters may be connected so as to start and stop machine operation, switch loading chutes, or perform functions associated with counting.

Special timers are furnished if desired for use in rate determination or the precise measurement of rotational speeds.

Dimensions: 14″ wide, 10″ high, and 8″ deep.

## Turnover Type Pickup

A new turnover type phonograph pickup with double needle cartridge, which plays 33⅓, 45, and 78 rpm records at the same pressure, has been manufactured by **Astatic Corp.**, Conneaut, Ohio.



The pickup is the Model CLD, which employs Model LQD cartridge. All three recordings are played at 8 grams pressure. The needles may be removed by light prying with a knife point or small screw driver; this may be performed without removing the cartridge.

When using a 78 rpm Audio-Tone test record, output voltages are 1.2 volts at 1,000 cps, and with a 33⅓ rpm Columbia 281 record, 0.9 volt at 1,000 cps.

*(Continued on page 58A)*

RCA scientists develop new *direct-reading* Loran instrument which simplifies problems of navigation.

## The **homing pigeon** goes to sea

Now science gives the navigator an improved "homing pigeon instinct," a way which—without checking the sun or the stars—he can head his ship directly home.

Already thoroughly proved, *Loran equipment* has been simplified through RCA research and engineering, so that almost anyone can learn to use it in a few minutes. Free of human error, readings appear *directly* on the instrument. A quick check gives position.

**Brain of this Loran system is a circuit developed at RCA Laboratories which splits seconds into millions of parts—and accurately measures the difference in the time it takes a pair of radio signals to travel from shore to ship.**

Given this information, the navigator, hundreds of miles from shore, can determine his position quickly and accurately. Loran's simplicity adapts it to every type of vessel from merchant ship to yacht. Manufactured by Radiomarine Corporation of America, a service of RCA, it is already being installed in U. S. Coast Guard rescue ships.

**The meaning of RCA research**

RCA's contribution to the development of this new direct-reading Loran is another example of the continued leadership in science and engineering which adds *value beyond price to* any product or service of RCA.

* * *

*The newest advances in television, radio, and electronics can be seen in action at RCA Exhibition Hall, 36 West 49th St., N. Y. Admission is free. Radio Corporation of America, RCA Building, Radio City, N. Y. 20.*

RCA

**RADIO CORPORATION of AMERICA**

*World Leader in Radio—First in Television*

**Wide band amplifiers to 1 m.c.**

HIGHEST PRACTICAL SENSITIVITY
.03 volts per inch.
DEMODULATOR — RETURN ELIMINATOR
SYNCHRONIZED LINEAR FM SWEEP
PHASING CONTROL
SYNUSOIDAL SWEEP
DIRECT CONNECTION TO VERTICAL
PLATES AVAILABLE

Ideal for industrial and laboratory applications, and for fast accurate receiver alignment. Model 195B. Write for complete information today.

World Famous for Accuracy for 39 Years

THE HICKOK ELECTRICAL INSTRUMENT CO.

10587 Dupont Ave., Cleveland 8, Ohio


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 58A)*

## New FM and TV Sweep Signal Generator

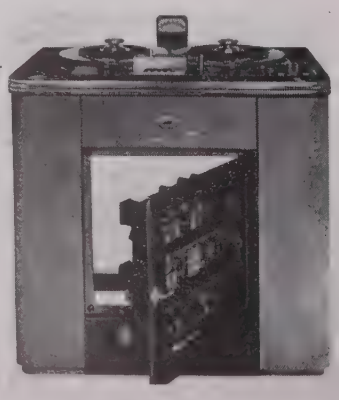
A new Model #SG, a sweep signal generator with a range from 0–227 Mc with no band switching, has been designed and developed by **Transvision, Inc.,** 385 North Ave., New Rochelle, N. Y.

The Model #SG has a sweep width from 0–12 Mc completely variable, and has a calibrated built-in marker generator.

The dial is calibrated in frequency. There is sufficient voltage output to permit stage-by-stage alignment. The crystal controlled output makes possible any crystal controlled frequency from 5–230 Mc. Unmodulated rf signal provides marker pips simultaneously with the main variable oscillator; these markers can be controlled as to output strength in the pip oscillator.

## Magnetic Tape Recorder

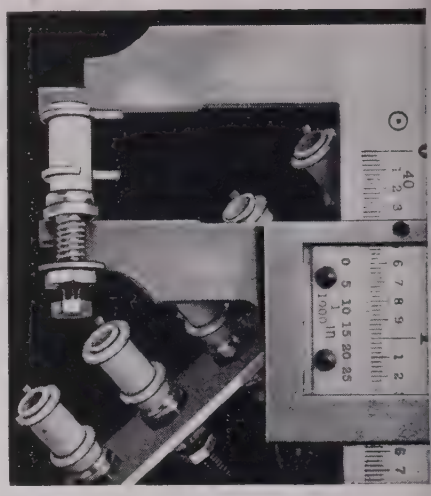
A new magnetic tape recorder for studio and broadcast station use is being offered by **Presto Recording Corp.,** P.O. Box 500, Hackensack, N. J., plant, Paramus, N. J.



A desireable feature of this recorder is the accessability to all working parts. The entire top panel hinges upwards, so that the lower side may be easily serviced. Both

*(Continued on page 61A)*


**EXTRA-SMALL... MOISTURE-RESISTANT**

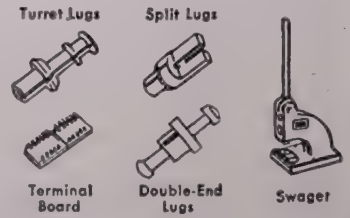


**New CTC Ceramic Coil Form Is Ideal For Many Sub-Miniature Component Applications**

Standing less than 5/8" high when mounted, and with a form diameter of only 3/16", CTC's new LST ceramic coil form fits easily into small spaces and hard-to-reach locations. In addition, its coil body of silicone impregnated ceramic (grade L-5, JAN-1-10) offers the advantage of extremely high resistance to moisture and fungi, and has well developed dielectric properties.

Mounting bushings and ring-type, adjustable terminals are of brass. Bushings are cadmium plated and terminals are silver plated. The powdered iron slug is adjustable. Accommodating solenoid or pie type windings, the LST is supplied as a coil form, or wound to specifications. Depending on the type of winding, inductance changes of approximately 2 : 1 can be expected.

You'll find the LST and many other *Guaranteed Components* fully described in CTC's new Catalog #300. This big illustrated booklet is packed with helpful information. Send for it today.




*Custom or Standard The Guaranteed Components*

CAMBRIDGE THERMIONIC CORP.
456 Concord Ave., Cambridge 38, Mass.

# News—New Products

**These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.**

*(Continued from page 60A)*

recording and playback amplifiers, as well as a separate regulator power supply, are vertically mounted on the front door of the cabinet. Access to both front and back of the amplifiers can be had without removal.

## Keyboard-Type Oscillator

The Model 150-AO-1/100K Keyboard oscillator, improved and redesigned, is at present being marketed by **Weinschel Engineering Co.,** Dept. I., 123 William St., New York 7, N. Y.

This instrument covers a range from 0.3 cps to 100 kc with decades of push buttons. In both lower ranges frequency is selected with four decades of push buttons, and in the top range with three decades together with a continuous control which covers a deviation of approximately ±1 per cent.

Between 100 and 100,000 cps, frequency may be varied in steps smaller than 0.1 per cent. Between 10 and 100 kc in steps smaller than 1 per cent, however adjustment to 1 cps is obtainable.

Description: 19 inches long, 17½ inches high, and 13 inches deep. Weight, 29 lbs.; power supply, 105–125 volts, 50–60 cps.

## Improved AF Measurement Equipment

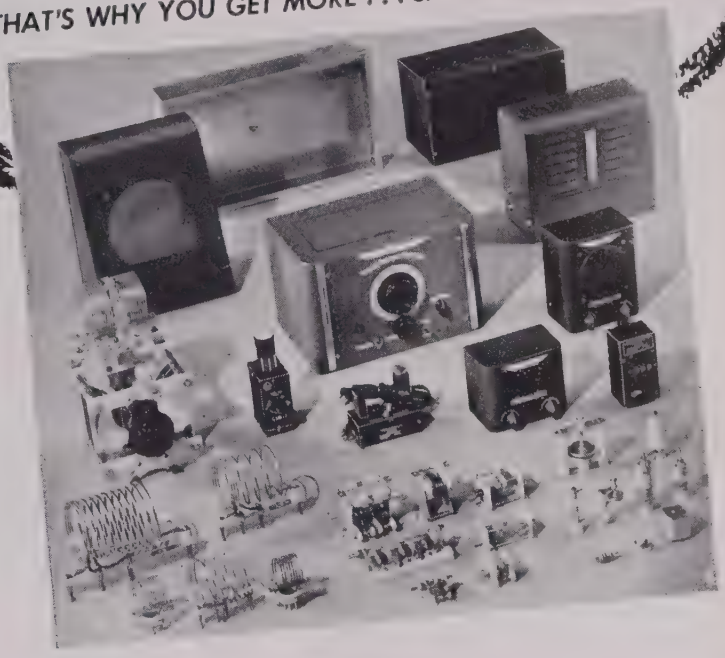
The Model GA-1002A, sound pressure measurement equipment with major improvements which include a specially isolated socket tip which effectively separates the microphone clamping structure from the preamplifier extension tube, is being manufactured by **Massa Laboratories, Inc.,** 3868 Carnegie Ave., Cleveland 15, Ohio.

The M-101 standard microphone which is part of the equipment has also been redesigned to provide increased polar symmetry of the mechanical structure, resulting in exact acoustic symmetry about the normal axis of the microphone even at frequencies above 20 kc. The range of the

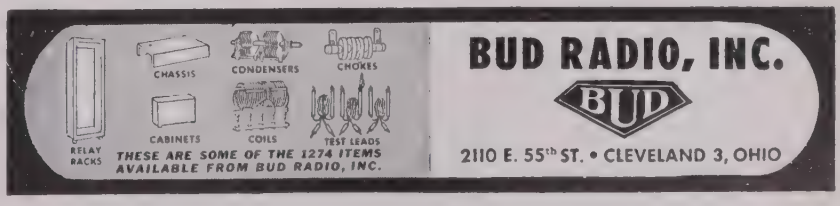
*(Continued on page 62A)*


WHO SAID IT'S SPECIAL? Not BUD!

THAT'S WHY YOU GET MORE . . . SAVE MORE WITH BUD.



● Many items which you may consider "special" may be a regular stock part in the large Bud line. Often a minor change or adaptation will convert a standard Bud product into a part that will fill your needs exactly. The Bud line offers you over 1200 radio and electronic products, enabling you to save time and money by eliminating "special" problems. Whatever your requirements for radio and electronic parts—try Bud first! Write for latest catalog.




*You Are Invited To Attend The First Annual*

AUDIO FAIR

Hotel New Yorker, New York City, October 27, 28, 29

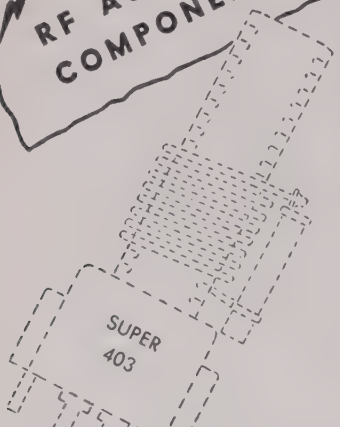
An event of utmost importance to Broadcast Engineers, Recordists, Sound-on-Film Men, Public Address Men, Audio Hobbyists and Distributors and Dealers.

Presenting for the first time, under one roof, an industry-wide display of audio equipment, components and accessories.

SPONSORED BY THE AUDIO ENGINEERING SOCIETY

NOTE THIS NAME

SUPER RF AUDIO TV COMPONENTS




● PRECISION PRODUCED

● PERFORMANCE PROVED

SUPER ELECTRIC PRODUCTS CORP.

*Pacing Electronic Progress With Ingenuity*

1057 Summit Ave., Jersey City 7, N. J.


# News—New Products

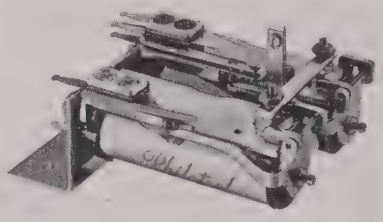
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 61A)*

instrument is such that sound pressures from less than 1 dyne/cm² to 20,000 dynes/cm² (160 db level) may be directly measured. A multiplier is available for extending the upper range to 200,000 dynes/cm² (180 db level). A built-in calibrating circuit permits setting the system gain so that 1 millivolt/dyne/cm² is delivered across the 10,000 ohm output circuit.

## New Interlocking Relay

A new interlocking relay, series 30500, consisting of two Type 2 Phil-trol relays, is the newest addition to the relays offered by **Phillips Control Corp.** 612 N. Michigan Ave., Chicago 11, Ill.



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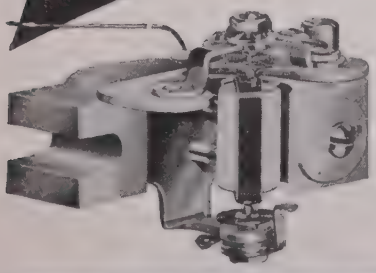


Precision machined soft iron pole pieces and alnico magnets, used by Burlington have no equal for permanent magnetic strength and uniform flux distribution. All ranges AC and DC available in rectangular or round case styles and are guaranteed for one year against defects in workmanship or materials. Refer inquiries to Dept. 1-99.

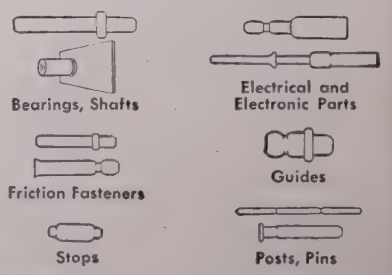
Burlington INSTRUMENT COMPANY
BURLINGTON, IOWA

# Choose right and make Big Savings on SMALL METAL PARTS

**COSTS HALVED!** Instead of turning and drilling parts like these from solid rod, or stamping and forming them, the BEAD CHAIN MULTI-SWAGE Process automatically swages them from flat stock. By doubling the production rate and eliminating scrap, this advanced process can save you as much as fifty percent of the cost of other methods.

**The BEAD CHAIN MULTI-SWAGE** Process produces a wide variety of hollow or solid metal parts—beaded, grooved, shouldered—from flat stock, tubing, rod, or wire—of any metal. Sizes to ¼" dia. and 1½" length.

**GET COST COMPARISON ON YOUR PARTS**—If you use small metal parts in quantities of about 100,000, don't overlook the almost certain savings of this high-speed, precision process. Send sketch, blueprint or sample part and our engineers will furnish facts about Multi-Swage economy. Or, write for Catalog. The Bead Chain Manufacturing Co., 60 Mountain Grove St., Bridgeport, Conn.

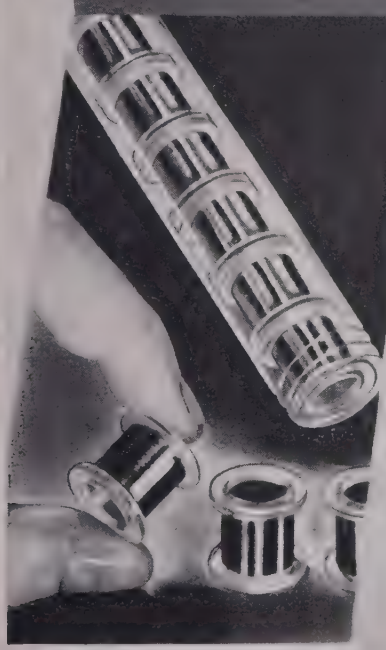



BEAD CHAIN MULTI-SWAGE PROCESS
TRADE MARK

*Etched*

# TUNGSTEN WIRE

- From .0004" to .00015" diameter and even smaller



- Accurate, uniform and smooth
- Also available in Molybdenum and other metals

*Write for details and List of Products*

**SIGMUND COHN CORP.**
44 GOLD ST. NEW YORK
SINCE 1901

# KENYON *Fits Your Production To A "T"*

**KENYON** "T's"—high quality, uniform transformers, are your best bet for development, production and experimental work. For over 20 years, the KENYON "K" has been a sign of skillful engineering, progressive design and sound construction.

Now—reduce inventory problems, improve deliveries, maintain your quality—specify KENYON "T's," the finest transformer line for all high quality equipment applications.

***New Catalog Edition! Write Today!***

**KENYON** new modified edition tells the complete story about specific ratings on all transformers. Our standard line saves you time and expense.

Send for your copy of our latest catalog edition *now!*

**KENYON TRANSFORMER CO., Inc.**
840 BARRY STREET · NEW YORK 59, N. Y.

*MEASUREMENTS CORPORATION*

# Peak-to-Peak VOLTMETER

**.0005—300 VOLTS**

## *MODEL 67*

Designed for accurate indication of the peak-to-peak values of symmetrical and asymmetrical waveforms, varying from low frequency square waves to pulses of less than five microseconds duration.

.0005-300 volts peak-to-peak, .0002-100 volts r. m. s. in five ranges. Semi-logarithmic, hand calibrated scales.

Provision for connection to 1500 ohm, 1 milliampere graphic recorder or milliammeter.

**INPUT IMPEDANCE: 1 megohm shunted by 30 mmfd.**
**DIMENSIONS: Height 7½", width 7", depth 8½". Weight 8 lbs.**
**POWER SUPPLY: 117 volts, 50-60 cycles, 35 watts.**

**MEASUREMENTS CORPORATION**
**BOONTON NEW JERSEY**

SKL

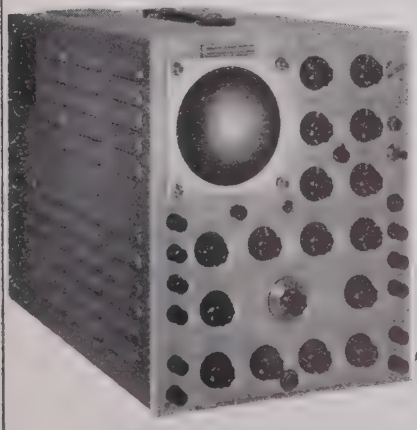
# 200 MC BAND WIDTH AMPLIFIERS

The SKL type 202 Wide-Band Chain Amplifier employs a new and unusual principle of amplification: the traveling wave circuit. This new design makes possible a bandwidth of from 100 KC to 200 MC with a gain of 20 db. Because of its low impedance — 200 ohms — existing coaxial cables can be used. Because of its flat response — ± 1.5 db — and low standing wave ratio — less than 1.5 db — the Model 202 offers new advantages in general laboratory measurement. The very fast rise time of the Model 202 is invaluable in oscillography, nuclear instrumentation and television applications.

**SKL** SPENCER KENNEDY LABORATORIES, INC.
185 MASSACHUSETTS AVE., CAMBRIDGE 39, MASS.



# TELEVISION?



*The Tektronix Type 511-AD Oscilloscope has been the choice of the leaders in television research as well as in TV transmitter and receiver design, production and maintenance.*

$845.00
f. o.b. Portland, Oregon

**Abridged Specifications Type 511-AD**

- 10 mc. band pass.
- Rise time .04 microsec.
- .25 microsec. video delay network.
- Deflection sensitivity .25 v/cm.
- Triggered, recurrent or single sweeps.
- Sweep speed continuously variable, .1 sec. to 1 microsec. (10cm)
- Sweep speed magnifier, 5x.
- Voltage calibration accuracy 5%.
- Sweep speed accuracy 10%.
- All DC supplies regulated.
- Portable. Total weight 50 pounds.
- Self-contained.

## CHECK ITS FEATURES

*We are confident that you, too, will find utility and usefulness in the Type 511-AD normally expected only from instruments considerably higher in price.*

TEKTRONIX INC.
712 S. E. HAWTHORNE BLVD. PORTLAND 14, OREGON


# News—New Products

**These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.**

*(Continued from page 62A)*

Interlocking relays may be furnished to operate on either ac or dc. When the lock-up relay is energized, it automatically locks in mechanically by means of a tension spring catch, which holds the armature in the energized position even though the circuit has been opened.

When the second relay, known as the release relay, is energized, the lock-up relay is automatically released from its mechanically held position. Other features are: relays may be equipped with as many as 12 springs; dc relays may be provided with copper slug coils, making them slow either to operate or release; contacts may be supplied either single or twin, and with contacts of various precious metals having ratings as high as 6 amperes, 110 volts ac, noninductive; relays may operate over a wide pressure range. A new descriptive catalog in color gives coil characteristics, contact assembly, and weight.

## Peak Pulse Voltmeter

The new Model 80, a Peak Pulse Voltmeter that is capable of readings at pulse widths under 1 microsecond and at 10 pps, has recently been designed and developed by **C. G. S. Laboratories, Inc.,** 36 Ludlow St., Stamford, Conn.

The Model 80 is an automatic slide-back type, and provides direct peak voltage readings of positive or negative pulses of widths from 0.25 microsecond to 20 milliseconds at repetitive rates from 10 to 50,000 pps, provided the duty cycle is under 50 per cent. Ranges of 10, 50, 100, 500, 1,000, and 5,000 volts are provided. Accuracy is 3 per cent full scale on any scale.

For detailed information consult H. Langstroth at **C. G. S.**

## RECENT CATALOGS

• • • A new "Commercial Radio Operators Q & A Manual," by Milton Kaufman, containing the questions used by the FCC in the April 1949 examination, with their answers, is to be released in August, by **John F. Rider, Publisher, Inc.,** 480 Canal St., New York 18, N. Y.

• • • A comprehensive catalog, #300, containing the most up-to-date information on the electronic and electrical components and their costs of **Cambridge Thermionic Corp.,** 445 Concord Ave., Cambridge 38, Mass.

*(Continued on page 67A)*

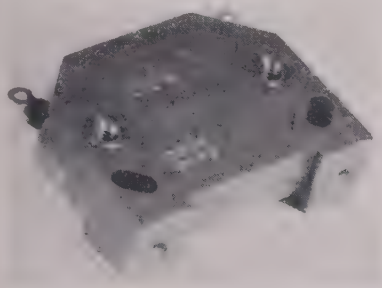
# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 64A)*

## Low Power Transmitter Mica Capacitors

A new line of transmitter mica capacitors with universal mounting, which are intended for use in low power transmitters for plate or grid coupling, filament, and plate by-pass applications, is announced by **Cornell-Dubilier Electric Corp.**, South Plainfield, N. J.



This line, the Faradon NF series, is similar to Type 9 except for different case style and mounting arrangement. The dimensions of these capacitors are $1\frac{13}{16}'' \times \frac{25}{32}'' \times 1\frac{7}{16}''$ over all, with a choice of a vertical mounting with insulated mounting holes tapped for $\frac{1}{2}''$ screw, or a horizontal mounting with brass terminal bushings tapped for a $\frac{5}{32}''$ screw. The latter type has insulated slotted mounting holes and insulated spacer feet to permit assembly against a chassis. Solder lug terminals and brass terminal bushings tapped for $\frac{5}{32}''$ screws provide an optional method of making connections. They are rated in a range from 0.00005 $\mu\mu$f with 2,500 volts dc to 0.03 $\mu\mu$f with 600 volts dc.

## New Pin Riveter For Light Operations

**Keller Tool Co.**, Grand Haven, Mich., announces production of a Pin Riveter, for very light riveting operations, with soft-metal tubular and standard rivets.

The new Pin Riveter is said to be suited to a variety of special jobs, such as setting small drive screws, driving brads in the assembly of wood, light peening and scaling operations on thin sheet-metal sections and bakelite.

The net weight of the Pin Riveter is 13 ounces; length, 6 1/16 inches. Piston diameter is 19/32 inch; stroke, $\frac{1}{2}$ inch. Tool has a speed of 9,000 blows per minute. Standard equipment consists of one blank rivet set, with special rivet sets available on order.

*(Continued on page 68A)*


NEW... Improved Wiring Eliminates Leakage

TYPE 12AT & TYPE 12ATK (KIT)

TRANSMISSION MEASURING SET

Range: 111 db. in 0.2 steps.
Frequency resp.: 0.1 db. from 0 to 20 kc.
Accuracy: 0.1 db.
Impedance, load section: 4, 8, 16, 50, 150, 200, 500, & 600 ohms.
Impedance, transm. set.: 50, 150, 200, 500 & 600 ohms.
Reference level: 1mw. into 600 ohms.
Circuit: "T", unbalanced.
Attenuators: 10x10, 10x1 & 5x0.2 db.
Load carr. cap.: Transm. sect. 1 w. Load section 10 w.

A precision Gain Set with specially developed wiring that permits no troublesome leakage and provides improved frequency characteristics. Available completely assembled, or in kit form—which permits the sale of a high accuracy instrument at a low price.

WRITE FOR DESCRIPTIVE BULLETIN

TECH LABORATORIES, INC.

Manufacturers of Precision Electrical Resistance Instruments

PALISADES PARK, NEW JERSEY

You can do every kind of soldering with this new 250 watt Weller Gun. Power-packed, it handles heavy work with ease—yet the compact, lightweight design makes it equally suited for delicate soldering and getting into tight spots.

Pull the trigger switch and you solder. Release the trigger, and off goes the heat—automatically. No wasted time. No wasted current. No need to unplug the gun between jobs. 'Over and under' position of terminals provides greater visibility with built-in spotlight. Extra 5¼" length and new RIGID-TIP mean real soldering efficiency.

Chisel-shape RIGID-TIP offers more soldering area for faster heat transfer, and new design gives bracing action for heavy jobs. Here you get features not found in any other soldering tool . . . advantages that save hours and dollars. Your Weller Gun pays for itself in a few months. Order from your distributor or write for bulletin direct.

SOLDERING TIPS—get your copy of the new Weller guide to easier, faster soldering—20 pages fully illustrated. Price 10c at your distributor, or order direct.

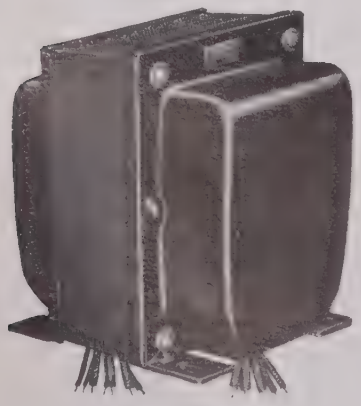
WELLER MANUFACTURING COMPANY

821 PACKER STREET • EASTON, PA.

# EAR and EYE TUNED

## TELEVISION TRANSFORMERS

This Acme Electric 500 V.A. Power Supply Transformer for television receivers, has been carefully engineered to provide the exact electrical characteristics required for larger sets. Hum-free operation has been attained thru both riveting and bolting core and varnish impregnating entire unit.



This larger V.A. capacity transformer, permits manufacturers to use only one transformer instead of two.

From standard laminations, sizes and standard mounting cases Acme Electric engineers can design exactly the transformers you need to improve your product. We invite your inquiry.

**ACME ELECTRIC CORP.**

449 Water St. Cuba, N.Y., U.S.A.

Acme Electric TRANSFORMERS

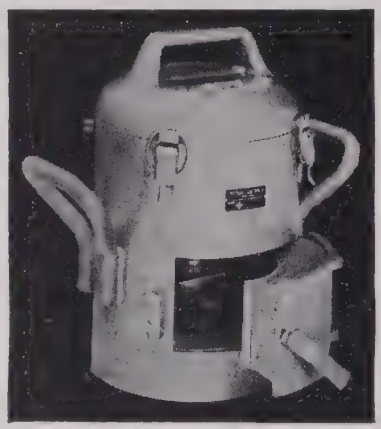

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 67A)*

## Vertical Lead Shield for Radiation Protection

A new vertical lead shield, Model 800, that incorporates new designed principles, has been developed by **Atomic Instrument Co.**, 160 Charles St., Boston 14, Mass.



The Model 800 is steel-cased, aluminum-lined and, the manufacturer claims, offers at least 1½ inch equivalent of lead shielding in all directions. The top is of aluminum and lead construction and, while removable, can be securely locked. The connector opening, located near the top of the cylinder, is aluminum-lined.

The interior is equipped with a lucite holder and is specially designed to be completely light-proof and background-proof.

Dimensions are as follows: inside, 5 inches diameter by 8½ inches high; outside, 9 inches by 14½ inches; door opening, $3\frac{5}{8}$ inches by 4 inches; weight, 250 lbs.

## New Microvolt Signal Generator

The new Model 292X, signal generator, a microvolt generator designed to cover both upper channel TV and mobile band frequencies on fundamentals, is announced by **Hickok Electrical Instrument Co.**, 10551 Dupont Ave., Cleveland 8, Ohio.

The manufacturer states that its major use will be in the coverage of mobile band frequencies for taxicabs, police departments, railways, ships, etc., for which no expanded scale instrument with accuracy to 0.05 per cent was previously available.

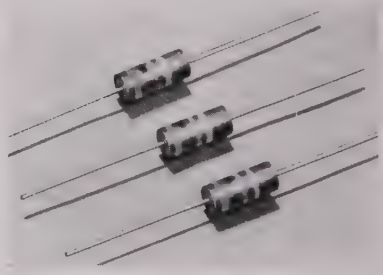
Model 292X covers all AM, FM, TV, and mobile frequencies; measures both input and output of units under test; has modulated and unmodulated output from 1 to 100,000 microvolts; may be externally modulated from 15 to 10,000 cps; employs decibel meter for faster servicing—over 100 inches of scale; and a self-contained crystal oscillator circuit.

Dimensions are $14'' \times 16\frac{1}{2}'' \times 8''$, weight 29 lbs.

For information write to H. D. Johnson at Hickok.

## New 2-Watt Fixed Resistor

The development of new 2-watt molded carbon composition resistors is announced by The **Electronic Components Div., Stackpole Carbon Co.**, St. Marys, Pa.



*(Continued on page 69A)*


From voice through UHF

**COMMUNICATION CIRCUITS**

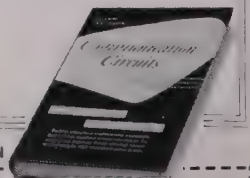
*Third Edition*

By Lawrence A. Ware and Henry R. Reed

The third edition of *Communication Circuits* gives all the basic principles of communication transmission lines and their associated networks . . . all the frequencies, including the ultrahigh . . . impedance matching . . . attenuation in wave guides . . . microwave transmission by means of rectangular and cylindrical wave guides and coaxial cables . . . and much more.

Many chapters have been enlarged; all are brought up-to-date.

1949
403 pages
202 illus.
$5.00



10 DAYS' EXAMINATION

ON APPROVAL COUPON

JOHN WILEY & SONS, INC.
440 Fourth Avenue, New York 16, N.Y.

Please send me, on 10 days' examination, a copy of Ware & Reed's COMMUNICATION CIRCUITS. If I decide to keep the book, I will remit $5.00 plus postage; otherwise I will return the book postpaid.

Name .....

Address .....

City .....Zone .... State.....

Employed by .....

(Offer not valid outside U.S.)

IRE-9-49

# News—New Products

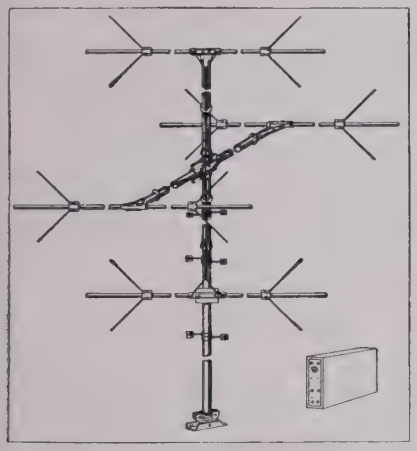
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 68A)*

These resistors are available in a complete range from 10 to 100,000 ohms and in standard tolerances of ±5, 10 or 20 per cent as required. The new resistors have been designed to meet JAN specifications. They are fully insulated and moisture resistant. A new anchoring method assures that lead strength will exceed the standard 10-lb. pull test. Standard RMA color coding is employed. The new resistors are 11/16 inches long by 0.312 inch in diameter.

## TV Antenna With Four Driven Elements

A new antenna designed to decrease cochannel interference, is announced by **Technical Appliance Corp.**, Sherburne, N. Y.



The Type 900 TV antenna has four driven elements, two in the vertical and two in the horizontal plane.

The manufacturer claims that with this new antenna it is now possible by means of a diplexer network to eliminate the cochannel interference present in many locations where two stations are on the same channel or adjacent channels and are located about 180° apart.

Type 900 is supplied with diplexer, which is mounted at the receiver. The diplexer serves as a matching transformer between the line and the receiver, eliminating any standing waves due to mismatch. It also serves as a reversing switch for witching directivity lobes.

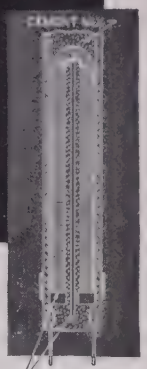
## Precision Micrometer Head

The announcement of production of a new type precision micrometer head, designed for the electronics industry is made by the manufacturer, **Frequency Standards Corp.**, P.O. Box 66, Eatontown, N. J.

*(Continued on page 70A)*


BRAND NEW!

★ Only two holes in chassis
★ Readily-wired lugs
★ 19/32" dia. 1½, 2, 2½ and 3" h.
★ 10, 15, 20 and 25 w.
★ Max. res. 6,000, 9,000, 12,000 and 15,000 ohms




STANDEE--ABOVE-CHASSIS-MOUNTED POWER RESISTOR . . .

★ Just what the underwriter ordered! Mounts ABOVE chassis. Takes heat out in the open. ⅜" hole clears terminals below. Mounting bracket takes self-tapping screw.

Wire winding on fibre-glass core, bent in hairpin with mica separator between legs, placed in ceramic tube filled and sealed with cold-setting inorganic cement.

★ Write on business letterhead for literature, sample and quotations.

1949 IS TV YEAR

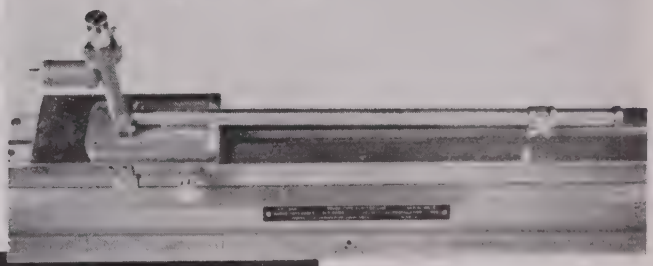
CLAROSTAT

Controls and Resistors

CLAROSTAT MFG. CO., INC. • DOVER, NEW HAMPSHIRE • In Canada: CANADIAN MARCONI CO., LTD. Montreal, P. Q., and branches



PRECISION



FTL-30A SLOTTED LINE

Designed for making impedance, standing wave ratio, and wavelength measurements in the range of 60 to 1000 megacycles per second.

Careful design and precision manufacture enable highly accurate measurements to be made with the line.

High sensitivity and selectivity due to efficient probe tuning.

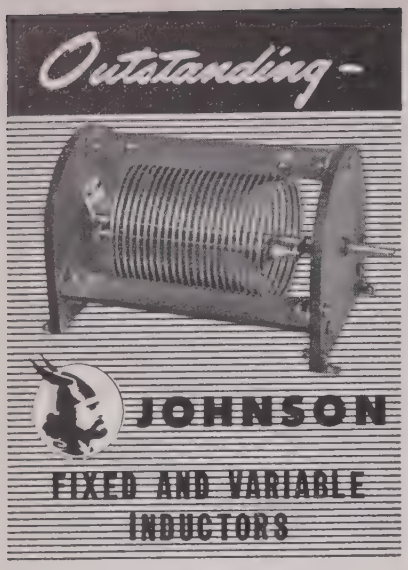
End connectors adapted to use of Type N or similar fittings for solid dielectric cables as well as for ⅞, 1⅝ and 3⅛ inch air lines.

Write for complete FTL-30A Brochure

Federal Telecommunication Laboratories, Inc.

An IT&T ASSOCIATE

500 WASHINGTON AVE. NUTLEY 10, N. J.




***For Every Application . . .***

Outstanding in every respect, JOHNSON Variable and Fixed Inductors are available in a wide variety of types to meet every electronic application. JOHNSON has available a wide range of standard models — or can build special types, in production quantities, on short notice.

Among the different types are:

**222 SERIES**
(Illustrated above)

For low power electronic heating and medium power transmitting. Internal sliding contact type. Mycalex insulation, conductor 1/2" copper strip nickel plated. Inductors of this standard type are wound to specific requirements.

**224 SERIES**

For high power application. Roller contact type. Approximate maximum inductance 75 uh with 3/8" tubing, 50 uh with 1/2" tubing. Cast aluminum end frames.

**226 SERIES**

For high frequencies. Rotating coil type. Optional variable pitch winding for wide frequency band coverage. Edgewise copper strip, silver plated. Wound to customer specifications.

**227 SERIES**

A high current Inductor especially adapted to Electronic Heating Equipment. Rotating coil type. Available in single or dual models, with or without coupling links. End frames and support bars, Mycalex. Conductor 3/4" flat wound silver plated copper.

**229 SERIES**

For low power transmitters. Rotating coil type. Smooth tuning! Available with 27 to 63 turns with inductance of 37 uh to 150 uh in standard models. Steatite or phenolic insulation. Wire sizes 12 and 16 gauge.

**TYPE M**

Inductance: built to any specified inductance from 10 uh up. Basic M design permits any length and diameter.

**TYPE VM**

Same as M except supplied with variable coupling rotors, flippers, or as variometers. Faraday screens may be incorporated to reduce electrostatic coupling.

**TYPE N**

Fixed Inductors wound with either copper strip, ribbon, tubing or wire. Inductance: built to any specified inductance from 10 uh up. May be supplied with either internal or external coupling winding.

**TYPE VN**

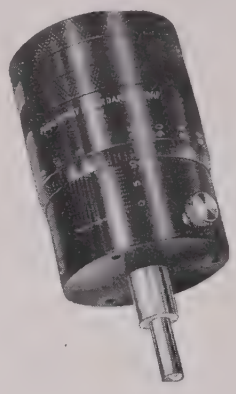
Same as N except variable. Main winding stationary with rotating winding connected as variometer or coupling inductor.

**E. F. JOHNSON CO.**
WASECA, MINNESOTA


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

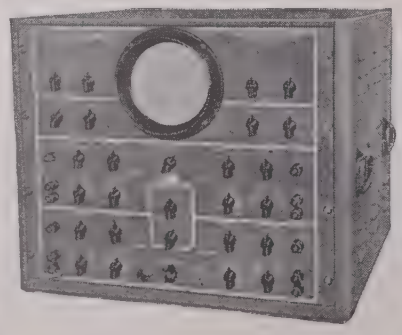
*(Continued from page 69A)*



The size of the thimble in all models is $2\frac{1}{8}$ inches in diameter. Readability is assisted by contrasting colors on the scale. The antibacklash screw thread, which compensates for thread wear, provides a positive spindle reading in either direction or rotation. The head is avilable in either English or Metric scales with either 1 inch or $\frac{1}{2}$ inch thread offered in either scale.

## New Four-Beam Oscillograph

A new four-beam cathode-ray indicator, capable of simultaneously displaying four related or unrelated independent phenomena on a single screen, has been made commercially available by the designer, **Special Products Section, Allen B. DuMont Labs., Inc.** 1000 Main Ave., Clifton, N. J.



This oscillograph is equipped with Type K1027P11 C-R tube, which contains 4 independent electron guns. It also contains its own power supply and horizontal amplifier for each channel. Sweep circuits and vertical amplifiers are not provided because the instrument was not intended for use with a record camera of the moving-film type.

The horizontal amplifiers are directly coupled, with conductive or capacitive inputs to the four channels. Each channel may be individually calibrated by means of an internal voltage calibrator. Selector switches permit either conductive or capacitive input couplings.


# Spectrum Analysis

**from AF to UHF**

***Faster and Simpler with these***

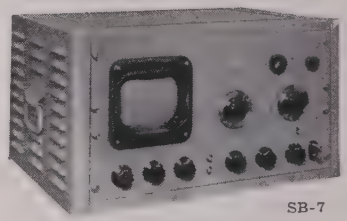
**Panoramic Instruments**

Whether your problem is investigation of noises, vibrations, harmonics, characteristics of AM, FM or pulsed signals, oscillations, cross modulation, transmission characteristics of lines and filters, monitoring, telemetering or any phenomena requiring spectrum analysis, these panoramic instruments will help collect information **faster, easier** and **more economically** by automatically visualizing spectral content.

**Panoramic Sonic Analyzer AP-1**
**Complete Audio Waveform Analysis in One Second**

Recognized as **THE** practical answer for analyzing waves of random or static character, the AP-1 automatically separates and measures complex wave components in only one second. Direct reading.

**Frequency Range:** 40-20,000 c.p.s., log scale.
**Input Voltage Range:** 500 μV-500V.
**Voltage Scale:** linear and two decade log, 60 db overall range.

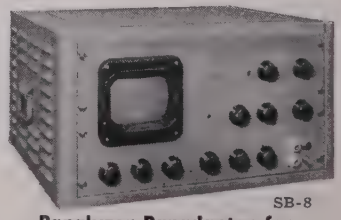


SB-7

**Panoramic Ultrasonic Analyzer**
**Entirely New for Ultrasonic Studies**

An invaluable new direct reading instrument, the SB-7 enables overall observation of the ultrasonic spectrum or very highly detailed examination of any selected narrow spectrum segment.

**Frequency Range:** 2KC-300 KC, linear scale.
**Scanning Width:** Continuously variable, 200 KC to zero.
**Input Voltage Range:** 1 mV-50V.
**Amplitude Scale:** linear and two decade log.



SB-8

**Panalyzor Panadaptor for**
**RF Spectrum Analysis**

Long accepted as the simplest and fastest means of observing segments of the RF Spectrum, Panadaptor units operate with superheterodyne receivers, which tune in the segment to be examined. Panalyzors use an external signal generator for this purpose and have a flat amplitude response for determining relative levels of signals.

Both are available in over a dozen standard models and types differing in . . . **Maximum Scanning Widths** ranging from 50KC to 20MC, continuously variable to zero. **Signal Resolution Capabilities** from 250KC down to 100 CPS.

***Write Now for Complete Technical Data***

**See these instruments demonstrated at the National Electronics Conference, Booth No. 5**

PANORAMIC RADIO PRODUCTS INC
10 SOUTH SECOND AVE.

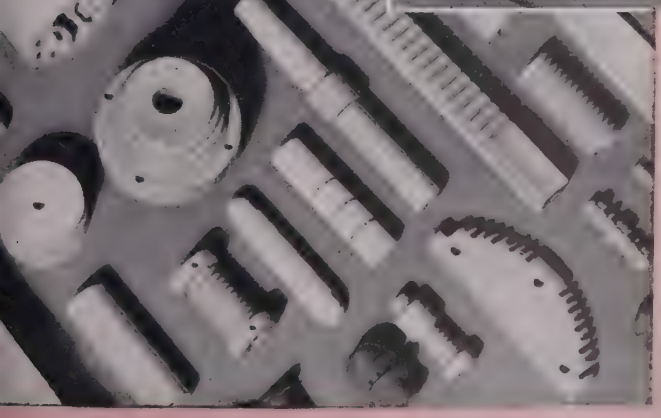
# ample kiln capacity

***safeguards AlSiMag quality and***

***helps keep deliveries on schedule***

**AlSiMag**
Reg. U. S. Pat. Off.

Side view of one of AlSiMag's tunnel kilns. All kilns, both circular and tunnel, are handled from one centralized control panel.



• Completely automatic controls hold firing temperatures within ± 2° C. in AlSiMag's kilns. As an extra safeguard, highly trained and skilled kiln operators are on duty every minute of the day and night. Recording instruments plus operator's hourly checks and records assure that all AlSiMag material is accurately fired.

## AMERICAN LAVA CORPORATION

48TH YEAR OF CERAMIC LEADERSHIP

CHATTANOOGA 5, TENNESSEE

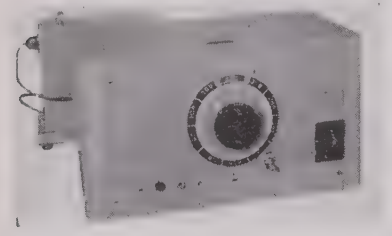
OFFICES: METROPOLITAN AREA: 671 Broad St., Newark, N. J., Mitchell 2-8159 • CHICAGO, 9 South Clinton St., Central 6-1721
PHILADELPHIA, 1649 North Broad St., Stevenson 4-2823 • LOS ANGELES, 232 South Hill St., Mutual 9076
NEW ENGLAND, 38-B Brattle St., Cambridge, Mass., Kirkland 7-4498 • ST. LOUIS, 1123 Washington Ave., Garfield 4959

# NEWS and NEW PRODUCTS

OCTOBER, 1949

## New Audio Oscillator

The new Model 50 audio oscillator, intended for use as a secondary standard for low frequency application, has been designed and developed by **C. G. S. Laboratories, Inc.**, 36 Ludlow St. Stamford, Conn



This oscillator operates in the range from 2,500 to 25,000 cps, accuracy ±0.1 per cent. Tube change and ±10 per cent line voltage change affect the frequency less than ±0.03 per cent. Temperature coefficient is of the order of 0.002 per cent per degree centigrade.

Detailed information is available from H. Langstroth at C. G. S.

## Polinear Recorder

The model PFR Polinear Recorder, which offers the combined ability of polar and rectilinear movement permitting the recording of angular patterns, frequency response characteristics, and other measurements, has been developed by **Sound Apparatus Co.** Stirling, N. J.

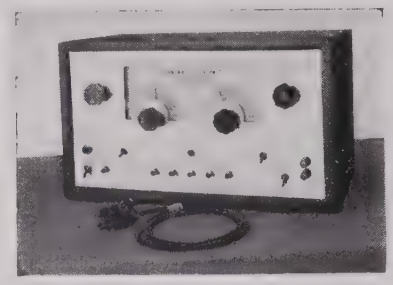
This instrument can record either ac or dc voltages. The turntable, 8½ inches×11 inches, is driven linearly by a synchronous motor and is rotated by a selsyn repeater.

Special combination charts, polar and semilog, are available; however, standard charts may be used.

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

## New Sweep Generator

An entirely electronic sweep generator, Type ST-4A, using a variable-permeability type sweep and having no moving components, has been developed by the **Specialty Div., General Electric Co.**, Electronics Park, Syracuse, N. Y



Frequency is continuously variable from 4 to 110 Mc and from 170 to 220 Mc with a linear sweep width of from 500 kc to greater than 15 Mc. High output voltage is available over the entire range.

Attenuation is continuously variable from maximum output down to 20 microvolts. Leakage is low, it is claimed, with stray fields of less than 10 microvolts, induced in a 2-inch loop 6 inches from the case in any direction.

Further information on this sweep generator is available from the Specialty Division.

## Rhombic Antenna Terminating Resistor

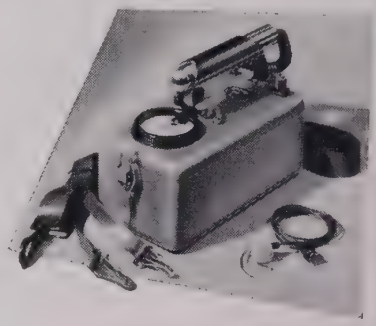
A new rhombic antenna terminating resistor #9079, which is two noninductive Ayrton-Perry wound 362.5 ohm resistors enclosed in glazed ceramic shell and vacuum sealed, is available to the industry from **Shallcross Mfg. Co.**, 520 Pusey Ave., Collingdale, Pa

Leads are brought out to terminal eyes which are designed for 7-strand #16-antenna wire. These resistors are rated at 25 watts dissipation and are designed to operate between −20°F to +120°F.

Over-all length 6⅛", diameter 2½".

## Nuclear Radiation Counter

A beta-gamma counting rate meter, with the counter located in the probe, has been developed by the **Instrument Div., Kelly-Koett Mfg. Co.**, 12 E. Sixth St., Covington, Ky

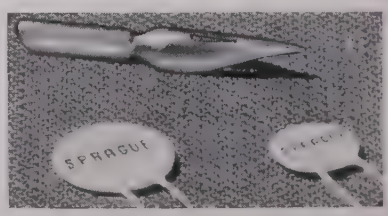


Described as Keleket Model K-800, this meter is housed in a cast magnesium-aluminum case, and is waterproof. The probe has a movable shield to differentiate between beta and gamma radiation. This has been accomplished without conventional interdispersed foils. The shield is stainless steel, 2 millimeters thick, and will exclude all but very high beta rays, the manufacturer claims.

Three ranges of gamma activity may be measured, 0.2, 2.0, and 20.0 mr/HR. The scale is also calibrated in 360, 3,600, and 36,000 counts per minute.

## Small Disk Ceramic Capacitors

New thin disk ceramic capacitors are the latest addition to the line of fixed capacitors manufactured by **Sprague Electric Co.**, North Adams, Mass.




The manufacturer asserts that these capacitors consists of a dime-sized ceramic plate of high dielectric constant with silvered electrodes fired on both faces of the disk. The leads are soldered to the silvering and the capacitors are coated with resin.

These components are available in ratings up to 0.01 or 2 × 0.004μf, 500 volts dc working.

Engineering Bulletin 601A supplies complete data.

*(Continued on page 39A)*

# MAGNETRONS – RADAR – PULSE EQUIPMENT

### MAGNETRONS

| Tube | Frq. Range | Pk. Pwr. Out | Price |
|---|---|---|---|
| 2J31 | 2820-2860 mc. | 265 KW. | $25.00 |
| 2J21-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 2J22 | 3267-3333 mc. | 265 KW. | $25.00 |
| 2J26 | 2992-3019 mc. | 275 KW. | $25.00 |
| 2J27 | 2965-2992 mc. | 275 KW. | $25.00 |
| 2J32 | 2780-2820 mc. | 285 KW. | $25.00 |
| 2J37 | | | $45.00 |
| 2J38 Pkg. | 3249-3263 mc. | 5 KW. | $35.00 |
| 2J39 Pkg. | 3267-3333 mc. | 87 KW. | $35.00 |
| 2J40 | 9305-9325 mc. | 10 KW. | $65.00 |
| 2J49 | 9000-9160 mc. | 58 KW. | $85.00 |
| 2J34 | | | $55.00 |
| 2J61 | 3000-3100 mc. | 35 KW. | $65.00 |
| 2J62 | 2914-3010 mc. | 35 KW. | $65.00 |
| 3J31 | 24,000 mc. | 50 KW. | $55.00 |
| 5J30 | | | $39.50 |
| 714AY | | | $25.00 |
| 718DY | | | $25.00 |
| 720BY | 2800 mc. | 1000 KW. | $50.00 |
| 720CY | | | $50.00 |
| 725-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 730-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 728 | AY, BY, CY, DY, EY, FY, GY | | $50.00 |
| 700 | A, B, C, D | | $50.00 |
| 706 | AY, BY, DY, EY, FY, GY | | $50.00 |
| Klystrons. | 723A/B $12.50; 707B W/Cavity | | $20.00 |
| | 417A $25.00 | 2K41 | $65.00 |

### PULSE EQUIPMENT

**MIT. MOD. 3 HARD TUBE PULSER:** Output Pulse Power: 11⁄4 KW (12 KV at 12 amp.). Duty Ratio: .001 max. Pulse duration: 5. 1.0 2.0 microsec. input voltage: 115 v. 400 to 2400 cps. Uses 1-715-B, 1-829-B, 3-'72's, 1-'73. New ..... $110.00

**APQ-13 PULSE MODULATOR.** Pulse Width .5 to 1.1 Micro. Sec. Rep. rate 624 to 1348 Pps. Pk. pwr. out 35 KW. Energy 0.018 Joules ..... $49.00

**TPS-3 PULSE MODULATOR.** Pk. power 50 amps. 24 KV (1200 KW pk): pulse rate 200 PPS, 1.5 microsec., pulse line impedance 50 ohms. Circuit—series charging version of DC Resonance type. Uses two 705-A's as rectifiers. 115 v. 400 cycle input. New with all tubes ..... $49.50

**APS-10 MODULATOR DECK** Complete, less tubes ..... $75.00

**APS-10** Low voltage power supply, less tubes ..... $18.50

### PULSE TRANSFORMERS

**G.E.K.-2745** ..... $39.50

**G.E.K.-2744-A.** 11.5 KV High Voltage, 3.2 KV Low Voltage @ 200 KW oper. (270 KW max.) 1 microsec. or 1/4 microsec. @ 600 PPS $39.50

**W.E. #D166173** Hi-Volt input transformer, W.E. Impedance ratio 50 ohms to 900 ohms. Freq. range: 10 kc to 2 mc. 2 sections parallel connected, potted in oil ..... $36.00

**W.E. KS** 9800 Input transformer. Winding ratio between terminals 3-5 and 1-2 is 1.1:1, and between terminals 6-7 and 1-2 is 2:1. Frequency range: 380-520 c.p.s. Permalloy core ..... $6.00

**G.E. #K2731** Repetition Rate: 635 PPS, Pri. Imp: 50 Ohms. Sec. Imp: 450 Ohms. Pulse Width: 1 Microsec. Pri. Input: 9.5 KV PK. Sec. Output: 28 KV PK. Peak Output: 800 KW. Riflar 2.75 Amp. ..... $64.50

**W.E. #D169271** Hi Volt input pulse Transformer ..... $27.50

**G.E. K2450A.** Will receive 13KV. 4 micro-second pulse on pri., secondary delivers 14KV. Peak power out 100KW G.E. ..... $4.50

**G.E. #K2748A.** Pulse Input, line to magnetron ..... $36.00

**#9280 Utah** Pulse or Blocking Oscillator XFMR Freq. limits 790-810 cy-3 windings turns ratio 1:1:1 Dimensions 1 13/16 x 1 1/8" 19/32 ... $1.50

### PULSE NETWORKS

**15A—1-400-50:** 15 KV, "A" CKT, 1 microsec., 400 PPS, 50 ohms imp. ..... $42.50

**G.E. #6E3-5-2000-50P2T,** 6KV, "E" circuit, 3 sections, .5 microsecond, 2000 PPS, 50 ohms impedance ..... $6.50

**G.E. #3E** (3-84-810; 8-2.24-405) 50P4T; 3KV, "E" CKT Dual Unit: Unit 1, 3 Sections. .84 Microsec.

**810 PPS,** 50 ohms imp.: Unit 2, 8 Sections, 2.24 microsec. 405 PPS, 50 ohms imp. ..... $6.50

**7.5E3-1-200-67P.** 7.5 KV, "E" Circuit, 1 microsec. 200 PPS, 67 ohms impedance, 3 sections .$7.50

**7.5E4-16-60.67P.** 7.5 KV, "E" circuit, 4 sections, 16 microsec. 60 PPS, 67 ohms impedance $15.00

**7.5E3-3-200-6PT.** 7.5 KV, "E" Circuit, 3 microsec. 200' PPS, 67 ohms imp., 3 sections .... $12.50

### DELAY LINES

**D-168184:** .5 microsec. up to 2000 PPS, 1800 ohm term. ..... $4.00

**D-170499:** .25/.50/.75. microsec. 8 KV. 50 ohms imp. ..... $16.50

**D-165997:** 1¼ microsec. ..... $7.50

### MAGNETRON MAGNETS

| Gauss | Pole Diam. | Spacing | Price |
|---|---|---|---|
| 4850 | ¾ in. | 5⁄8 in. | $12.50 |
| 5200 | 21/32 in. | ¾ in. | $17.50 |
| 1300 | 1 5⁄8 in. | 1 5/16 in. | $12.50 |
| 1860 | 1 5⁄8 in. | 1½ in. | $14.50 |

Electromagnets for magnetrons ..... $24.50 ea.

**TUNABLE PKGD. "CW" MAGNETRONS**

QK 61 2975-3200 mc. QK 62 3150-3375 mc.
QK 60 2800-3025 mc. QK 59 2675-2900 mc.
New, Guaranteed ..... Each $65.00

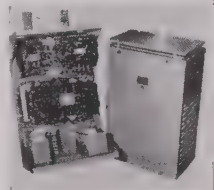
**BC 1277A** Sig. Generator ..... $300.00
**APR4.** Receiver 300-2000 mc. ..... $475.00
**CPD 10137** Dehydrating Unit ..... $425.00
**APR5A.** Complete antenna. 10 cm. waveguide ..... $185.00

### 1KW-FM STATION

General Electric Kilowatt Amplifier
Model 4BT2A1 Type BT2A
Serial RC 25
General Electric 250 Watt Exciter
Model 4BT1A1 Type 3T1A
Serial CC833
General Electric Station Monitor
Model 4BM1A1 Type BM1A
Serial WC268
General Electric Power Supply
Model BP241 Type BF2A
Serial WC547
General Electric Transmitter Console
Model 4BC3A1 Type BC3A
Serial WC5
Type BX-2A Two Bay Circular Antenna with Transmission Line, Elevators and Matchers. 100 Feet of 1 5⁄8 coax, transmission line including 90° elbows.
Dehydrator for transmission line
Desk and Chair for Transmitter Console.

**WRITE FOR PRICE AND INFO.**

### VOLTAGE REGULATOR



Mfg. Raytheon: Navy CRP-301407: Pri: 92-138 v. 15 amps. 57 to 63 cy. 1 phase. Sec: 115 v. 7.15 amp. .82 KVA. .96 PF. Contains the following components:

**REGULATOR TRANSFORMER:** Raytheon UX9545. Pri: 92-138 v. 60 cy. 1 PH. Sec: 200/580 v. 5.55/5.26 amps, 400 v rms test.

**FILTER REACTOR:** .1 56 hy, 5 amps, 4000 v Raytheon UX 9547.

**TRANSFORMER:** Pri: 186 v, 5 amps; Sec: 115 v, 7.2 amps. Size: 12" x 20" x 29". Net wt. approx. 250 lbs. Entire unit is enclosed in grey metal cabinet. New, as shown ..... $99.50

### 200 MC COAXIAL PLUMBING

Right Angle Bend ..... $35.00
T Section ..... $55.00
T Section with Adapter to 7⁄8" in rigid coax ..... $65.00

5CM.

2" x 1" RT. ANGLE BEND CHOKE TO COVER. SILVER PLATER ..... $38.50
WAVEGUIDE MIXER CV-12A/APR-6 ... $55.00
RAPID W. G. FASTENING CLAMPS ..... $5.00

### CPN-6 3CM RADAR BEACON EQUIPMENT

Complete sets available in unused condition. Write for price and information.

### SUPER SONICS

**QCU Magneto** striction head RCA type CR 278225. New ..... $75.00
**Stainless Steel** streamlining housings for above ..... $18.50
**QBG Driver Amplifier.** New ..... $200.00
**QCU Magneto** striction head coil plate assembly, new ..... $14.50
**QCQ—2/QCB Magneto** striction head coil plate assembly ..... $14.50

### R. F. EQUIPMENT

**LHTR. LIGHTHOUSE ASSEMBLY.** Part of RT-39/APG-5 & APG-15. Receiver and Transmitter Lighthouse Cavities with assoc. Tr. Cavity and Type N CPLG. To Rcvr. Uses 2C40, 2C43, 1B27. Tuneable APX 2400-2700 MCS. Silver plated ..... $49.50

**XTAL DIODES** 1N21 $1.00, 1N23 $1.50, 1N22 $1.50, 1N23 $2.95

**APS-2 10CM RF HEAD COMPLETE WITH HARD TUBE** (715B) Pulser, 714 Magnetron 417A Mixer all 7⁄8" rigid coax. incl. rcvr. front end ..... $210.00

**Beacon lighthouse cavity 10 cm** with miniature 28 volt DC FM motor. Mfg. Bernard Rice ..... $47.50 ea.

**T-128/APN-19 10 cm. radar Beacon transmitter package,** used, less tubes ..... $59.50 ea.

**SO-3 "X" band 3 cm RF package,** new complete, including receiver unit as illustrated on Page 337, Volume 23 RAD LAB Series ..... $375.00 ea.

**Pre-amplifier cavities** type "M" 7410590GL to use 446A lighthouse tube. Completely tunable, Heavy silver plated construction ..$37.50 ea.

**RT32/APS 6A RF HEAD.** Compl. with 725A Magnetron magnet pulse xfmr. TRA-ATR. 723 A/B local osc. and beacon mount, pre amplifier. Used but exc. cond. ..... $97.50

**AN/APS-15A** "X" Band compl. RF head and modulator, incl. 725-A magnetron and magnet, two 723A/B klystrons (local osc. & beacon), 1B24, TR, rcvr-ampl. duplexer, HV supply, blower, pulse xtmr. Peak-Pwr Out: 45 KW apx. Input: 115, 400 cy. Modulator pulse duration .5 to 2 micro-sec. apx. 13 KV Pk Pulse. Compl. with all tubes incl. 715-B, 829B, RKR 73, two 72's. Compl. pkg., new ..$210.00

**APS-15B.** Complete pkg. as above, less modulator ..... $150.00

**"S" BAND AN/APS-2.** Complete RF head and modulator, including magnetron and magnet, 417-A mixer, TR, receiver, duplexer, blower, etc., and complete pulser. With tubes, used, fair condition ..... $75.00

**10 CM, RF Package.** Consists of: SO Xmtr.-receiver using 2J27 magnetron oscillator, 250 KW peak input. 707-B receiver-mixer ..$150.00

### MICROWAVE ANTENNAS

**SO-3 RADAR 3 CM. SURFACE SEARCH ANTENNA.** Complete with 24 VDC Drive Motor, Selsyn, Gear Mechanisms, "X" Band Slotted "Peel" Reflector. Less Plumbing ..... $135.00
As Shown

**APS-15 Antennas.** New .... $99.50

**AN MPG-1 Antenna.** Rotary feed type high speed scanner antenna assembly, including horn parabolic reflector. Less internal mechanisms. 10 deg. sector scan. Approx. 12'L x 4'W x 3'H. Unused. (Gov't Cost—$4500.00) ..... $250.00

**APS-4 3 cm. antenna.** Complete. 14½ dish. Cutler feed dipole directional coupler, all standard 1" x ½" waveguide. Drive motor and gear mechanisms for horizontal and vertical scan. New, complete ..... $65.00

**AN/TPS3.** Parabolic dish type reflector approx. 10' diam. Extremely lightweight construction. New in 3 carrying cases ..... $89.50

**RELAY SYSTEM PARABOLIC REFLECTORS:** approx. range: 2000 to 6000 mc. Dimensions: 4' x 3' rectangle, now ..... $35.00

**TDY "JAM" RADAR ROTATING ANTENNA.** 10 cm. 30 deg. beam. 115 v.a.c. drive. New ..... $100.00

**SO-13 ANTENNA,** 24" dish with feedback dipole 360 deg. rotation, complete with drive motor and selsyn. New ..... $128.00
Used $45.00

**DBM ANTENNA,** Dual, back-to-back parabolas with dipoles. Freq. coverage 1,000-4,500 mc. No drive mechanism ..... $65.00

**AS125/APR** Cone type receiving antenna, 1080 to 3208 megacycles. New ..... $4.50

**140-600 MC. CONE** type antenna, complete with 25' sectional steel mast, guys, cables, carrying case, etc. New ..... $49.50

**ASD** 3 cm. antenna, used, ex. cond. .... $49.50

**YAGI ANTENNA AS-46A. APG-4, 5 elements** $14.50 ea.

### SF-1 RADAR

**10 CM** surface search using PPI and "A" Scope. 115 VDC input, complete with spares. 14 cases ..... $2800.00

ALL MERCHANDISE GUARANTEED. MAIL ORDERS PROMPTLY FILLED. ALL PRICES F.O.B. NEW YORK CITY. SEND MONEY ORDER OR CHECK ONLY. SHIPPING CHARGES SENT C.O.D. RATED CONCERNS SEND P. O. MERCHANDISE SUBJECT TO PRIOR SALE

## COMMUNICATIONS EQUIPMENT CO.

131 "I 10" Liberty St., New York, N.Y. Att: P. J. Plishner Cable "Comsupo" Ph. Digby 9-4124

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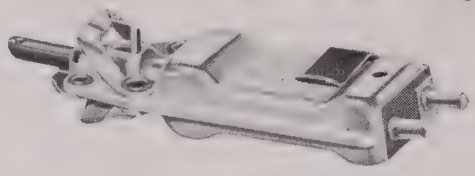
APG5
APR
APS2
APS3
APS4
APS6
APS10
APS15
ABA
QBF
QBG
QCQ
WEA
RAK
CPN3
CPN6
DAB
RC145
RC148
YD
ZA

WEBSTER ELECTRIC

# Featheride

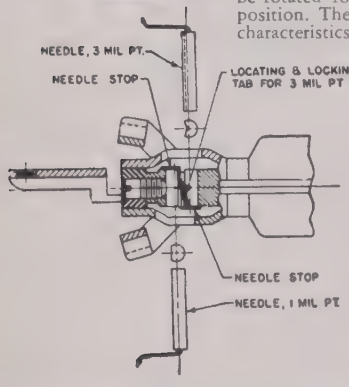
## CRYSTAL CARTRIDGES

**that meet the requirements for 33⅓, 45 and 78 RPM Records**



**MODEL F-16**

The model F-16 is an all-purpose crystal cartridge employing two separate needles to permit playing both fine-cut and standard records . . . with a single tone arm and three-speed turntable. The cartridge can be rotated 180° in the arm to bring the proper needle into playing position. The model F-16 is a quality cartridge with ideal response characteristics.




**SPECIFICATIONS**

APPLICATION: 33⅓ RPM, 45 RPM and 78 RPM.

TRACKING PRESSURE: 7 grams for all speeds.

CONSTRUCTION: Stamped aluminum half-shells.

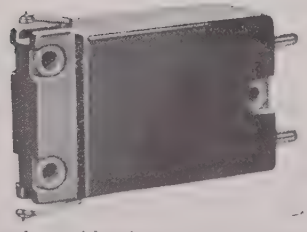
FRONT BRACKET: Extends through front of pick-up arm to permit rotating cartridge 180.°

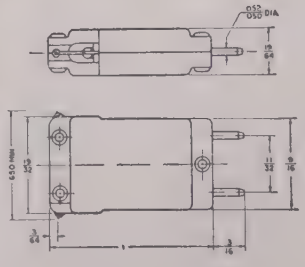
STYLE: Osmium-tipped, replaceable. 1-mil point for 33⅓ and 45 RPM, 3-mil point for standard 78 RPM.

TERMINALS: Pin type, grounded or ungrounded.

OUTPUT: 8 volt for 33⅓ and 45 RPM, 1.2 volts for standard 78 RPM.

**MODEL A-1**





The Model A-1 crystal cartridge is newly developed . . . miniature in size and ideally adapted for tone arms of modern styling and function. It mounts either a 1-mil or 3-mil point stylus or both, making it applicable to all types of recordings in use today. Tracking pressure is only 7 grams . . . meeting the requirements of 33⅓ and 45 RPM as well as the standard 78 RPM records. Adaptor brackets supplied for mounting in arms originally designed for standard cartridges.

**SPECIFICATIONS**

APPLICATION: 33⅓, 45 and 78 RPM recordings.

CONSTRUCTION: Bakelite housing.

TERMINALS: Pin type.

STYLI: Osmium- or Sapphire-tipped.

TRACKING PRESSURE: 7 grams.

OUTPUT: 1 volt at 1000 cps.

**WEBSTER ELECTRIC**

RACINE WISCONSIN

Established 1909

Export Dept.: 13 E. 40th Street, New York (16), N. Y. Cable Address "ARLAB" New York City

**"Where Quality is a Responsibility and Fair Dealing an Obligation"**

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 39A)*

## Midget-Can Electrolytic Capacitors

The latest type PRS midget-can electrolytic capacitor in reduced sizes are being marketed by **Aerovox Corp.**, 740 Belleville Ave., New Bedford, Mass.

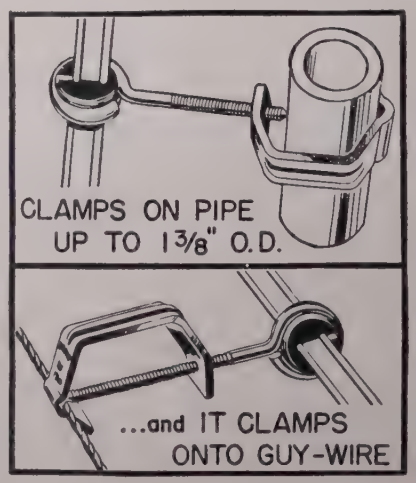
Illustrated is the type PRS 450 volt, 8 μf "Dandee," which is placed next to a cigarette for comparison. The size is 1½ inches long by 13/16 inch diameter.

These electrolytics are available in single-section ratings from 25 to 700 volts dc working, 4 to 100 μf and in dual-section from 25 to 450 volts dc working, 8-8 to 100-100 μf.

In the high-capacitance low-voltage series, they have ratings from 6 to 25 volts dc working, 100 to 2,000 μf.

## TV Lead-in Clamps

A new line of TENNA-CLAMPS, stand-off insulators, designed to clamp on to masts, cross-arms, gutters, and guy-wires for supporting TV lead-in lines is now being marketed by **Mueller Electric Co.**, 1583 E. 31st St., Cleveland 14, Ohio.




The manufacturer claims that the one standard size of clamp is adaptable for solving various problems in lead-in wire support. All metal parts are weather-proofed, and the insert is of polyethylene.

*(Continued on page 43A)*

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 42A)*

## Correction Notice

A dc microammeter and magnetic amplifier, Type 100, has been designed to measure low dc by **W. S. MacDonald Co., Inc.,** 33 University Rd.. Cambridge 38, Mass.

Incorrectly described in our August issue, the Type 100 has an input resistance of 50 ohms and a sensitivity of 1 *microampere* full scale. Input may be overload $\frac{1}{4}$ ampere without damage.

This instrument may be used as a dc amplifier, as such it will actuate a 1-ma, 1,400-ohm recorder directly.

## Recent Catalogs

• • • In the May issue of *The Experimenter*, a high power, low-speed (600 rpm) stroboscope, and a versatile voltage divider are discussed. The organ is published by **General Radio Co.,** 275 Massachusetts Ave., Cambridge 39, Mass.

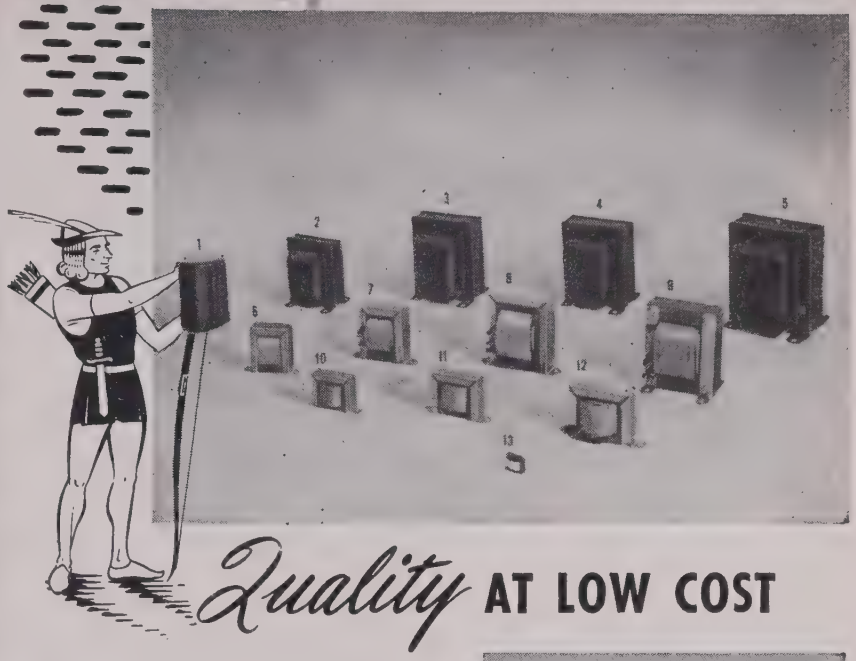
• • • A desk size Army-Navy Connector Specifications (AN-C-591) Chart with the latest insert arrangements shown in detail at half scale for use by aircraft, radio, communication engineers, and designers, by **Cannon Electric Development Co.,** Catalog Dept., 3209 Humbolt St., Los Angeles 31, Calif.

• • • An 8-page bulletin with information and technical data on dc motors for timing applications, and the performance characteristics of Model 9200 dc motor, may be obtained by writing to E. B. Hamlin, **Haydon Mfg. Co.,** Torrington, Conn. Specify Engineering Bulletin #1.

• • • A 35-page catalog August #854 in color with complete design specifications and dimensions of all their screw products, by **The Bristol Co., Mill Supply Div.,** Waterbury 91, Conn.

*(Continued on page 44A)*


**ADC** *Yeoman* **TRANSFORMERS**



*Quality* **AT LOW COST**

High quality, low cost transformers for a wide range of applications are provided by **ADC** in its new Yeoman transformer line.

Many features of the **ADC** Quality Plus and Industrial series . . . widely known for their unvarying high standard of performance . . . are incorporated in the Yeoman line.

The low prices of the new Yeoman line are made possible by improved production engineering methods, simplified types of construction and standardization of parts.

Engineers, experimenters and amateurs will find in the Yeoman series the transformers for their needs.

**PICTURED ITEMS**

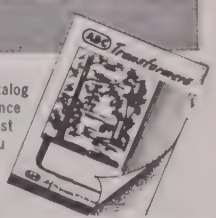
| Type | Description |
|---|---|
| (1) 708A Band Pass Filter: | 200-3000 cps |
| (2) 517D Power: | Pri. 38 VA<br>Sec. #1, 240-0-240 @ 40 ma DC<br>Sec. #2, 5 V @ 2 amp<br>Sec. #3, 6.3 V @ 1.6 amp |
| (3) 517H Power: | Pri. 104 VA<br>Sec. #1, 300-0-300 @ 125 ma DC<br>Sec. #2, 5 V @ 3 amp<br>Sec. #3, 6.3 V @ 4.5 amp |
| (4) 517J Power: | Pri. 109 VA<br>Sec. #1, 350-0-350 @ 125 ma DC<br>Sec. #2, 5 V @ 3 amp<br>Sec. #3, 6.3 V @ 4.5 amp |
| (5) 517N Power: | Pri. 174 VA<br>Sec. #1, 400-0-400 @ 200 ma DC<br>Sec. #2, 5 V @ 3 amp<br>Sec. #3, 6.3 V @ 5.5 amp |
| (6) 516E Filament: | Pri. 9 VA<br>Sec. 6.3 V CT @ 1 amp |
| (7) 516C Filament: | Pri. 19 VA<br>Sec. 5.0 V CT @ 3 amp |
| (8) 516B Filament: | Pri. 31 VA<br>Sec. 2.5 V CT @ 10 amp |
| (9) 517A Filament: | Pri. 72 VA<br>Sec. 6.3 V CT @ 10 amp |
| (10) 416C Choke: | 8.5 hy @ 50 ma DC |
| (11) 416G Choke: | 8.0 hy @ 85 ma DC |
| (12) 516F Filament: | Pri. 24 VA<br>Sec. 6.3 V CT @ 3 amp |
| (13) 208F Input: | Microphone<br>Pri. 50/200<br>Sec. 62500/250000 |

**VISIT US AT THE AUDIO FAIR**

Recent developments in new equipment will be displayed by Audio Development Co. at the Audio Engineering Society's "Audio Fair" in Hotel New Yorker, Oct. 27, 28 and 29. Walter E. Lehnert, noted design engineer and **ADC** vice president, will be there prepared to discuss special transformer design problems with you.

*New*

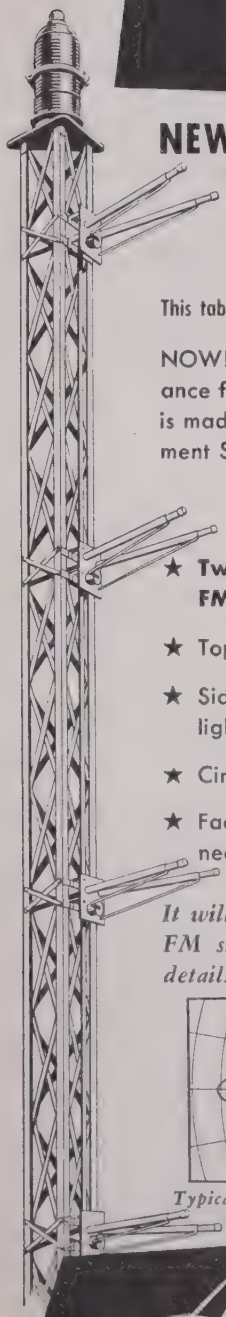
The new ADC catalog will be a convenience in selecting almost any transformer you may need. Send for your copy today.



**ADC** *Audio* **DEVELOPMENT CO.**

2855-13th AVENUE SOUTH, MINNEAPOLIS 7, MINN.

# GIVES YOU TWICE AS MUCH POWER GAIN PER DOLLAR!



## NEW *Andrew* MULTI-V FM ANTENNA

| TYPE | NO. OF BAYS | POWER GAIN | PRICE |
|---|---|---|---|
| 1308 | 8 | 7.3 | $2800 |
| 1304 | 4 | 3.7 | 850 |
| 1302 | 2 | 1.6 | 320 |

This table shows you why the new Andrew Multi-V is your best FM antenna buy!

NOW! Minimize your investment in equipment. Get top performance for only half the cost. The new Andrew Multi-V FM antenna is made and guaranteed by the World's Largest Antenna Equipment Specialists. It's another Andrew "First."

## FEATURES

★ **Twice as much power gain per dollar as any other FM transmitting antenna!**

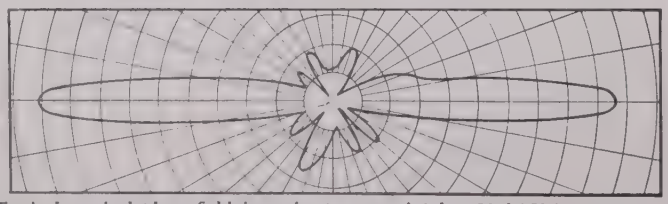
★ Top performance, yet half the cost of competitive antennas.

★ Side mounting construction permits installation on towers too light to support heavier antennas.

★ Circular radiation pattern.

★ Factory tuned to required frequency — no further adjustments necessary.

*It will* pay you *to use the Andrew Multi-V Antenna on your FM station. Write for Bulletins 86 and 186 for complete details TODAY.*



*Typical vertical plane field intensity pattern of 4 bay Multi-V FM Antenna.*

Andrew CORPORATION
363 EAST 75th STREET · CHICAGO 19

TRANSMISSION LINES FOR AM-FM-TV · ANTENNAS · DIRECTIONAL ANTENNA EQUIPMENT
ANTENNA TUNING UNITS · TOWER LIGHTING EQUIPMENT · CONSULTING ENGINEERING SERVICES

*World's Largest Antenna Equipment Specialists*


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 43A)*

• • • A new Engineering Data Sheet #558, which describes the latest types of coil tube fasteners, and shows typical assemblies, may be obtained from **The Palnut Co.**, 94 Cordier St., Irvington, N. J.

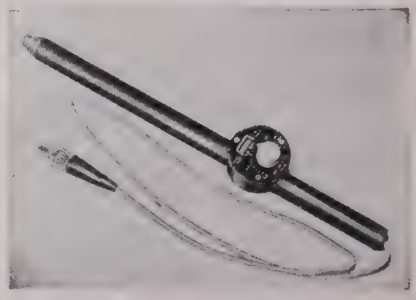
• • • A 24-page booklet, 21P8-46, describing insulation resistance testing with a "Megger," and a new color catalog, Bulletin 21-05-46, to be used in selecting from 10 types of "Megger" instruments covering ranges from 0.01 ohm to 10,000 megohms, by **James G. Biddle Co.**, 1316 Arch St., Philadelphia 7, Pa.

• • • An illustrated color folder with a description of a wide line of crystals, and the FS-344 Frequency Standard, is at present available from **James Knights Co.**, Sandwich, Ill.

• • • A 36-page bound catalog of instrumentation for radioactivity measurement, describing a wide range of instruments and accessories with information about application is ready for distribution by **Nuclear Instrument & Chemical Corp.**, 223-233 W. Erie St., Chicago 10, Ill.

## New Voltmeters Check Up To 30,000 Volts

Inexpensive, high-voltage voltmeters checking voltages up to 30,000 volts are now being manufactured by **Industrial Devices, Inc.**, Edgewater, N. J.



The Hi-Volt is available in two models. Model 500 is designed for checking the voltage output of transformers, such as for oil burner ignition, gas-discharge display signs, etc. Model 520 is for electronic high-voltage uses, such as television, oscillographs, etc.

The High-Volt utilizes a neon-lamp indicator in place of the usual meter movement. The knob is turned until neon lamp extinguishes. Voltage is then read directly off scale where pointer rests.

Heavily insulated and using a multi-megohm multiplier, the High-Volt test prod is 7 inches long, thus assuring user of sufficient reach to keep away from "hot" leads. Model 500 draws less than 1 milliampere, while Model 520 draws less than 300 microamperes at full scale reading.

*(Continued on page 45A)*

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 44A)*

## Package Circuit Assembly For TV Receivers

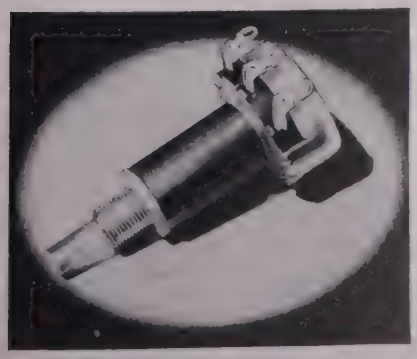
Following the trend of component manufacturers endeavoring to reduce production time and save space, a new package circuit assembly, known as the "Vertical Intergrator Network," has been produced by **Centralab, Div. Globe-Union, Inc.,** 900 E. Keefe Ave., Milwaukee, 1, Wis.

This printed electronic circuit consists of four capacitors and four resistors, terminating in three leads, as against sixteen connections when using standard components. In size the assembly is 1 9/16 inches long, $1\frac{1}{8}$ inches wide, and 3/16 inch thick.

A condensed version, which covers the balance of TV circuits, is a smaller model with three capacitors and three resistors.

## High-Voltage Controls

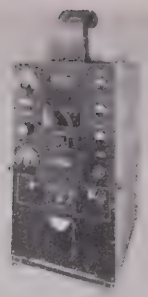
Increased insulation, necessary with controls used in TV, oscillograph, and other high-voltage circuits, may be obtained (on special order) by use of an improved coupler feature with most types of controls manufactured by **Clarostat Mfg. Co.,** Washington St., Dover, N. H.



*(Continued on page 46A)*

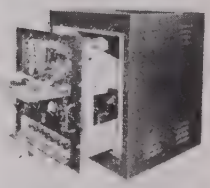
If the Problem is ELECTRONIC

...look to B&W for the answer



2 KW AMPLIFIER

CONTROL UNIT

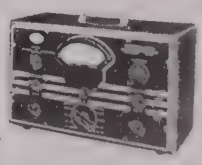


DUAL DIVERSITY CONVERTER

RECEIVER ASSEMBLY

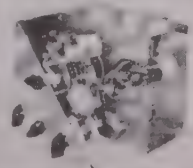
From amplifiers to electronic repeaters . . . from diversity converters to complete receiver assemblies, test instruments and frequency multiplier units, B & W equipment is backed by men who have spent a lifetime in the electronic field . . . men who know the problems of radio and electronics and how to solve them.

Modern, up-to-date facilities are ready to convert the designs of these engineers into components or complete assemblies, designed and fabricated to withstand the toughest assignments and carrying the B & W trade-mark, recognized the world over for excellence.



B&W DISTORTION METER

B&W ALL BAND FREQUENCY MULTIPLIER



*Write for the latest B & W Catalog to: Dept. PR-109*

BARKER & WILLIAMSON, INC.

237 Fairfield Avenue Upper Darby, Pa.

*Laboratory and Research Instruments*

ENGINEERED FOR ENGINEERS

OSCILLOSYNCHROSCOPE

Model OL-15B

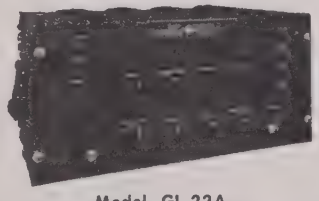
Designed for maximum usefulnes in laboratories doing a variety of research work, this instrument is suited to radar, television, communication, facsimile, and applications involving extremely short pulses or transients. It provides a variety of time bases, triggers, phasing and delay circuits, and extended-range amplifiers in combination with all standard oscilloscope functions.

*THESE FEATURES ARE IMPORTANT TO YOU*

- Extended range amplifiers: vertical, flat within 3 db 5 cycles to 6 megacycles, full tube deflection; horizontal, flat within 1 db 5 cycles to 1 megacycle.
- High sensitivity: vertical, 0.05 RMS volts per inch; horizontal 0.1 RMS volts per inch.
- Single-sweep triggered time base permits observation of transients or irregularly recurring phenomena.
- Variable delay circuit usable with external or internal trigger or separate from scope.
- Sawtooth sweep range covers 5 cycles to 500 Kilocycles per second.
- 4,000-volt acceleration gives superior intensity and definition.

For complete data, request Bulletin RO-910

SWEEP CALIBRATOR



Model GL-22A

This versatile source of timing markers provides these requisites for accurate time and frequency measurements with an oscilloscope:

- Positive and negative markers at 0.1, 1.0, 10, and 100 micro-seconds.
- Marker amplitude variable to 50 volts.
- Gate having variable width and amplitude for blanking or timing.
- Trigger generator with positive and negative outputs.

Further details are given in Bulletin RC-910.

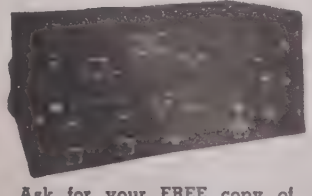
SQUARE-WAVE MODULATOR AND POWER SUPPLY

Model TVN-7

Here is the heart of a super high frequency signal generator with square-wave, FM, or pulse modulation. Provides for grid pulse modulation to 60 volts, reflector pulse modulation to 100 volts, square-wave modulation from 600 to 2,500 cycles. Voltage-regulated power supply continuously variable 280-480 or 180-300 volts dc. For additional data and application notes, see Bulletin RM-910.

STANDING WAVE RATIO METER AND HIGH GAIN AUDIO AMPLIFIER

Model TAA-16



- Standing wave voltage ratios are read directly on the panel meter of this sensitive, accurate measuring instrument.
- Frequency range 500 to 5,000 cycles per second.
- Two input channels with separate gain control for each.
- "Wide-band" sensitivity 15 microvolts full scale.
- "Selective" sensitivity 10 microvolts full scale.
- Bolometer/crystal switch adjusts input circuit to signal source.

Write for Bulletin RA-910 containing full details of this useful instrument

Ask for your FREE copy of our brochure illustrating and describing all Browning products.

In Canada, address Measurement Engineering Ltd., Arnprior, Ontario.

Export Sales
9 Rockefeller Plaza
Room 1422, New York 20

BROWNING
Laboratories, Inc.
Winchester, Mass.
ENGINEERED FOR ENGINEERS


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

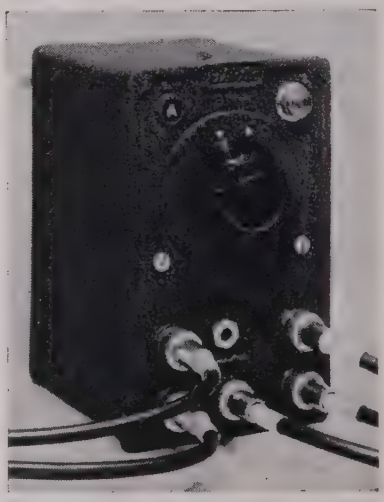
*(Continued from page 45A)*

Designated as Type 56–125 high-voltage coupler, this control has a plastic straight-through shaft in place of the previous insulating strip joining separate sections of the metal shaft. An insulating tube further isolates the control proper from its mounting bushing.

Control-to-ground breakdown rating is better than 10,000 volts.

## Adding Component for Analogue Computors

The K3-A adding component, which delivers from one to four input signals, and which has an adjustable additive steady level up to 20 per cent of the range, is being offered by **George A. Philbrick Researches, Inc.,** 230 Congress St., Boston, Mass.



Either or both outputs may be employed, giving plus or minus the direct sum of the inputs in use. Through tandem interconnection, any number of signals may be combined in sums or differences.

In the K3 analogue line, each component is self-contained and performs an individual function as part of a computing system. Each measures approximately 4×5×7 inches, weighs about 5 lbs., has 5-pin input and output connectors for 110 volts, 60 cps.

## New Impedance Meter

For the measurement of impedances from 0.1 to 100,000 ohms over a wide frequency range, the "Impedometer" has been developed by Edward S. Shepard, Sr. of Boston College and is being manufactured by **Electrodyne Co.,** 899 Boylston St., Boston 15, Mass.

*(Continued on page 47A)*

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 46A)*

The "Impedometer" provides a means for comparing the voltage drop across the unknown impedance and across a resistive standard, when the same current is present in both circuits. In making this comparison, the meter is used in conjunction with a suitable oscillator and vacuum-tube voltmeter.

## Microscope for Disk Recording Analysis

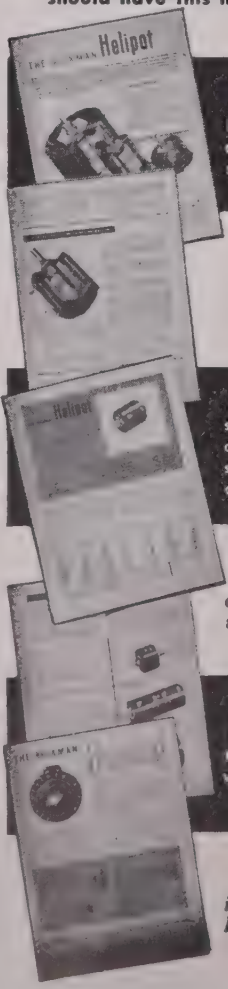
The Model #231 microscope, with self light source and reticle for groove analysis and surface quality testing, has been placed on the market by **Clarkstan Corp.**, 11927 W. Pico Blvd., Los Angeles 34, Calif.

Magnification of either 20 or 40 times is offered. For calculation of lines per inch, width of groove, or groove-to-land ratio, a reticle has been incorporated for direct measurement with divisions of 0.004 inch or 0.002 inch for the respective powers.

*(Continued on page 48A)*


# *Do you have This Helpful* Helipot *and* Duodial *Catalog?*

**Do you have complete data on the revolutionary new *HELIPOT*—the helical potentiometer-rheostat that provides many times greater control accuracy *at no increase in panel space*?. . . or on the equally unique *DUODIAL* that greatly simplifies turns-indicating applications? If you are designing or manufacturing any type of precision electronic equipment, you should have this helpful catalog in your reference files . . .**



***It Explains*** – the unique helical principle of the HELIPOT that compacts almost *four feet* of precision slide wire into a case only 1¾ *inches* in diameter – over *thirty-one feet* of precision slide wire into a case only 3½ *inches* in diameter!

***It Details*** – the precision construction features found in the HELIPOT . . . the centerless ground and polished stainless steel shafts—the *double* bearings that maintain rigid shaft alignment—the positive sliding contact assembly—and many other unique features.

***It Illustrates*** – describes and gives full dimensional and electrical data on the many types of HELIPOTS that are available . . . from 3 turn, 1½" diameter sizes to 40 turn, 3" diameter sizes . . . 5 ohms to 500,000 ohms . . . 3 watts to 20 watts. Also Dual and Drum Potentiometers.

***It Describes*** – and illustrates the various special HELIPOT designs available—double shaft extensions, multiple assemblies, integral dual units, etc.

***It Gives*** – full details on the DUODIAL—the new type turns-indicating dial that is ideal for use with the HELIPOT as well as with many other multiple-turn devices, both electrical and mechanical.

*If you use precision electronic components in your equipment and do not have a copy of this helpful Helipot Bulletin in your files, write today for your free copy.*

THE Helipot CORPORATION, SOUTH PASADENA 6, CALIF.

# NOW... R. F. ATTENUATION NETWORK FOR *YOUR* WORK

To meet the increasing needs for accurate, dependable instruments to attenuate UHF, The Daven Company now offers RF attenuation boxes. These units are notably compact, provide a wide range of attenuation and are moderately priced.

—SPECIFICATIONS—

CIRCUIT: Pi network.
STANDARD IMPEDANCES: 50 and 73 ohms. Other impedances on request.
RESISTOR ACCURACY: ± 2% at D.C.
IMPEDANCE ACCURACY: Terminal impedance of loss network essentially flat from 0—225 MC.
MOUNTING: Cabinet Type or Rack Mounting Available.
NO. OF STEPS: Types: 640, 641, 642, 643 — 8 Push Buttons
Types: 650 and 651 — 10 Push Buttons
RECEPTACLES: Army-Navy Types UG-58/U or UG-185/U Supplied

| TYPES | IMPEDANCE | LOSS |
|---|---|---|
| RFA 640 & 641 | 50 & 73 | 1, 2, 3, 4, 10, 20, 20, 20, DB STEPS (80 DB TOTAL IN 1 DB STEPS) |
| RFA 642 & 643 | 50 & 73 | 2, 4, 6, 8, 20, 20, 20, 20, DB STEPS 100 DB TOTAL IN 2 DB STEPS |
| RFA 650 & 651 | 50 & 73 | 1, 2, 3, 4, 10, 10, 10, 20, 20, 20, DB 100 DB TOTAL IN 1 DB STEPS. |

—APPLICATIONS—

- In signal and sweep generators.
- In field strength measuring equipment.
- Nucleonic and atomic research.
- Television receiver testing.
- Wide-band amplifiers.
- Pulse amplifiers.
- Any application where attenuation of UHF is required.

For additional information write to Dept. IE-8

**THE DAVEN CO.**
191 Central Avenue Newark, N.J.

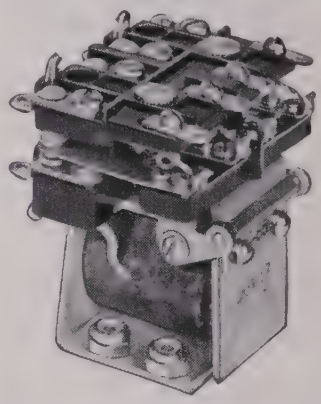

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 47A)*

## Power Relay

Described as having been manufactured to meet aircraft specifications and, therefore, capable of meeting rigid control requirements, the Type "DO" power relay is available from **American Relay & Controls, Inc.,** 4925 W. Flournoy St., Chicago 44, Ill.

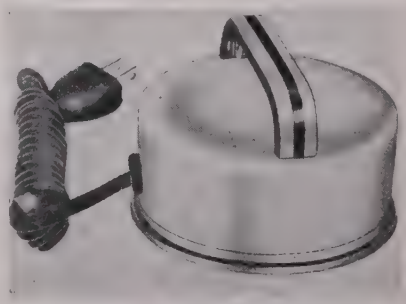


This relay is available in contact combinations up to 4-pole, double-throw. The terminals and contact arms are mounted on moulded phenolic panels. The coil is of cellulose acetate sealed construction.

Contact rating is 10 amperes at 115 volts ac, noninductive, or 10 amperes at 32 volts dc, noninductive. Coils are available for continuous duty for operation up to 230 volts ac, 60 cps, or 115 volts dc.

## Magnetic Tape Eraser

A device for erasure of reels of magnetic tape without running the tape past the erase head has been developed by the **Accessories Div., Amplifier Corp. of America,** 398-1 Broadway, New York 13, N. Y.



Described as the "Magnerasor," the manufacturer claims that this eraser removes all normal and overloaded signal from all types of tape, and is able to lower the residual noise level as much as 3 to 6 db below that of unused tape.

The erasure is accomplished by placing the "Magnerasor" on the reel and moving it around the circumference of the reel. The life of the tape is lengthened by elimination of physical contact with the erase head.

*(Continued on page 49A)*

# Positions Wanted

*(Continued from page 54A)*

### COMMUNICATIONS ENGINEER

B.S.E.E. 1947. 2 years carrier telephony, Signal Corps radio-link Age 27, married, 2 children. Now employed in Boston, wants research, design, station construction, sales engineering, teaching, or technical writing in central to southern Maine. 2 years design of high-frequency and microwave antennas. Box 332 W.

### ELECTRICAL ENGINEER

B.E.E. registration applied, age 28, single. 3 years' communications experience. 1 year servo-mechanism experience. Desires position in servo-mechanism in growing concern. Location, midwest or east. Box 333 W.

### ELECTRONIC TECHNICIAN

High school graduate. 2 years U. S. Coast Guard radio and radar school. 2 years at RCA Institutes. 5 years' experience in radio and radar maintenance and installation with U. S. Coast Guard. 3 years with American Airlines as radar technician in transmitter band experimental radar laboratory. Box 334 W.

# News—New Products

**These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.**

*(Continued from page 49A)*

## Increased Wattage for Soldering Guns

With the aid of a new method of transformer core winding, a more efficient soldering gun is now being manufactured by **Weller Mfg. Co.**, 808 Packer St., Easton, Pa.

Previously held to 135 watts, due to bulk and weight of the transformer, the new guns have a 250-watt capacity by use of a machine that winds the transformer core from strip steel onto the primary and secondary coils.

Described as Model WD-250, this gun has no increase in size, a few ounces increase in weight, and a heating time of 5 seconds.

## Universal Bridge

The #1150 Universal Bridge has been added to the laboratory instrument line of electronic equipment of the **Freed Transformer Co.**, 1718-36 Weirfield St., Brooklyn 27, N. Y.

*(Continued on page 56A)*


DESIGN TIPS FROM CHIEF ENGINEER FLEXY

"Study that illustration a minute. It won't take you long to see the many design possibilities you gain by using S.S.White remote control flexible shafts to connect variable elements to their controls.

"For instance, the *flexible* shaft coupling gives you a free hand in locating the elements independently of their controls. This is mighty important when it comes to meeting space, wiring and servicing requirements or when you're working for top circuit efficiency.

"As for the control knobs . . . you get the same freedom in positioning *them*. This means that you remove many limitations on your cabinet designs and can provide more convenient tuning.

"So, when your circuit design includes variable elements, think of S.S.White flexible shafts. This is a tip many designers of electronic equipment have used to good advantage."

WRITE FOR THIS FLEXIBLE SHAFT HANDBOOK

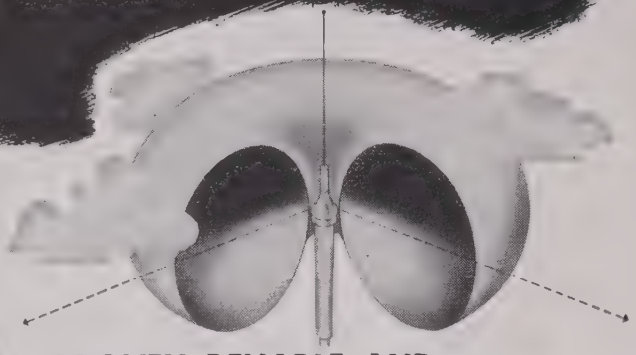
It contains 260 pages of facts and technical data on flexible shafts and how to select and apply them. Write for a copy.

S.S.White MAKES IT RIGHT

S.S.WHITE INDUSTRIAL DIVISION
THE S. S. WHITE DENTAL MFG. CO.
DEPT. G 10 EAST 40th ST., NEW YORK 16, N. Y.
FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

One of America's AAAA Industrial Enterprises

# It's CP for COAXIAL HALF-WAVE DIPOLE ANTENNAS for two-way mobile service



## PROVEN RELIABLE AND EFFECTIVE OVER THE YEARS

CP Antennas use one of the most effective — and elemental — forms of antennas serving radio communications. Simple physically and electrically, CP Antennas have earned a reputation for reliability.

CP Coaxial Antennas are ruggedly constructed of selected materials to give satisfactory commercial service under severe operating conditions. They are recommended for both transmission and reception. Power handling capacity is limited only by the rating of the feed line. All antennas feature rust-proof construction throughout with necessary accessories for simple, positive installation.

### Ask for your copy of CP Bulletin 106

This new bulletin, compiled by the engineering staff of Communication Products, provides complete data on CP antenna construction, as well as detailed specifications and operational information. Fully illustrated with photographs and schematic sketches. Call or write CP, now, for Bulletin 106 or literature on any of the products listed below.

YOU CAN DEPEND ON THESE CP PRODUCTS

- ✓ LO-LOSS SWITCHES
- ✓ TEFLON TRANSMISSION LINE
- ✓ AUTO-DRYAIRE DEHYDRATORS
- ✓ COAXIAL DIPOLE ANTENNAS
- ✓ TOWER HARDWARE

Communication Products Company, Inc.

KEYPORT CP NEW JERSEY


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

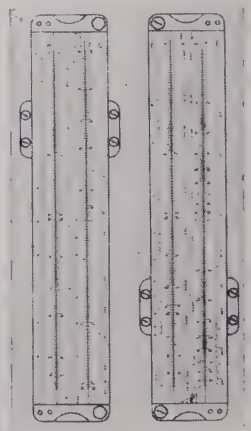
*(Continued from page 55A)*

Designed for measurements of inductors, capacitors, and determination of resistive and reactive components of i - pedances, the #1150 has a range of 20 to 20,000 cps, with accuracy to 1 per cent. It is used as a Maxwell, Hay, resonance, series-resistance capacitor, and parallel-resistance capacitor bridge.

Further information is available from Freed.

## Six-Inch Log Slide Rule

A 6-inch log slide rule with computational accuracy comparable to a 10-inch rule, incorporating 16 computing scales, may be obtained from **Pickett & Eckel, Inc.,** 5 S. Wabash Ave., Chicago 3, Ill.



Described as Model 300, this rule is constructed of a magnesium alloy with optical tongues and grooves machined to 0.001 inch for permanent alignment.

On the front, scales LL1, A-B, T, S, C-D, and LL2 are inscribed, on the reverse are LL3, DF-CF, CIF, CI, C-D, and L.

An instruction manual, written by Prof. M. L. Hartung of the University of Chicago, is included.

## Metal Screen Shielding

Metal screen, described as Lectromesh, suitable for shielding purposes may now be obtained in standard "counts" or designed to your specifications from **C. O. Jellif Mfg. Corp.,** Southport, Conn.

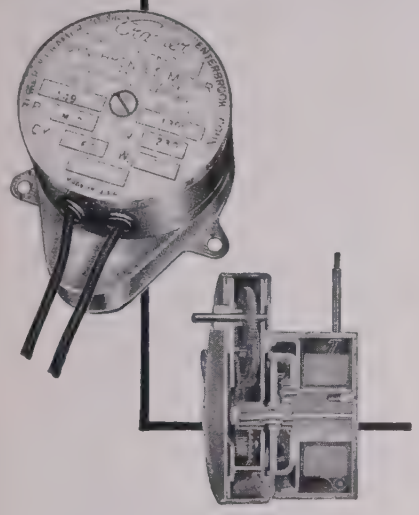
Lectromesh is a screen formed by electroplating copper, nickel, or a combination of both onto a rotating cylindrical matrix.

Standard production includes from 25 to 400 "counts" per square inch. Widths range up to 36 inches, lengths to 100 feet.

*(Continued on page 57A)*

Cramer

TYPE SX
SYNCHRONOUS
MOTORS



Cramer Type SX Synchronous Motors are highly efficient permanent magnet type motors that produce an exceptionally high torque. Self-starting . . . quick start and stop . . . operate at synchronous speed only. Close tolerance of magnetic field construction and precision alignment of gear train assure long, uninterrupted service.

**APPLICATION**

Designed for applications requiring a constant speed at a given frequency, Cramer Type SX Motors are widely used throughout the instrument and control fields to fill the gap between the low torque clock motors and the fractional horsepower group.

**CHARACTERISTICS**

*High Torque:* 30 in. oz. at 1 RPM, 60 cy. *Quick Response:* Reach synchronous speed within ½ to 2 cy. Stop within 1 pole of motion on 240 RPM rotor shaft (1/60 sec.). *Speeds:* Standard gear trains from 60 RPM through 1/24 RPH. *Cycles:* Available for 25, 50 and 60 cy. operation. *Coils:* Easily replaceable. *Lubrication:* Sealed within housing containing rotor and gear train.

SEND FOR BULLETIN 10B
THE R. W. CRAMER COMPANY, INC.
Box #12, Centerbrook, Conn.

INTERVAL — CYCLE — IMPULSE — PERCENTAGE TIMERS
RUNNING TIME METERS — GEARED SYNCHRONOUS MOTORS

8CR49

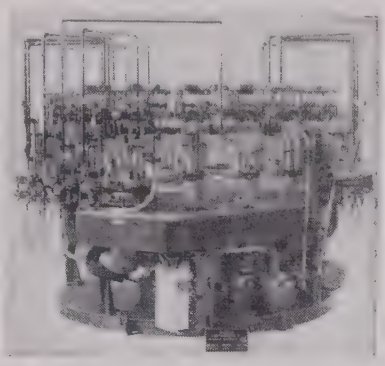
# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 56A)*

## Cathode-Ray Tube Sealing Machine

A new machine to be used in cathode-ray-tube manufacture has been placed on the market by **Kahle Engineering Co.**, 1309 Seventh St., North Bergen, N. J.



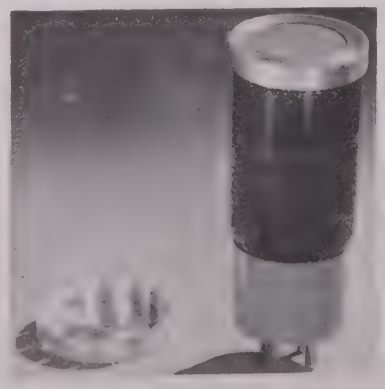
This machine is constructed to handle interchangeable adaptors which enable it to seal 16 tubes up to 12½ inches, or 12 up to 16 inches per cycle of operation.

The manufacturer claims the close tolerances to which these sealers are built holds shrinkage to a minimum.

Complete information on all types of tube machinery and consultation information on individual problems is available from Kahle.

## Thin Mica End-Window Counter

A new Model D31, end-window type Geiger-Müller counter, with the mica window available in thicknesses from 2 to 3.9 milligrams per square centimeter, is available from **Nuclear Instrument & Chemical Corp.**, 223 W. Erie St., Chicago 10, Ill.

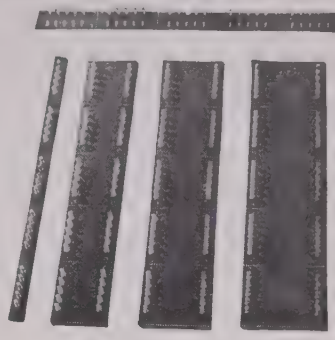


The D31 has a plateau length of 200 to 300 volts, with a slope of only 3 per cent per hundred volts. Threshold voltage is between 1,050 and 1,300 volts, and counting life is at least $10^8$ counts.

An identical counter, D32, with window thicknesses between 1.5 and 2.0 milligrams per square centimeter is also available.

*(Continued on page 58A)*

COVERING THE ENTIRE RANGE OF COMPONENTS...



CTC ALL-SET Boards Speed Up Work On Assembly Lines And In Laboratories

CTC *ALL-SET* Boards are designed to save time and cut costs over a wide range of standard assembly operations.

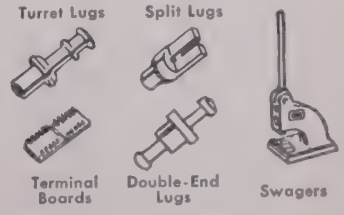
Boards with Type 1724 Turret Lugs come in four widths: ½", 2", 2½", 3"; and in thicknesses of 3/32", ⅛", 3/16". A Board with Type 1558 Turret Lugs, for miniature components, is 1 1/16" wide, with thicknesses of 1/16" and 3/32" only (Type X1401E). This new miniature Board completes the CTC ALL-SET group.

Boards are all of laminated phenolic, in five-section units scribed for easy separation. Each section is drilled for 14 lugs, with 10 mounted, except X1401A (½" wide), which is drilled for 7 lugs per section, with 5 mounted. All lugs are solidly and precisely swaged, and each whole board is ready for assembly.

**Custom-Built Boards**

are an important specialty at CTC. Avail yourself of our long experience in handling the widest range of materials and jobs — many of them requiring special tools — and in all types of work to commercial or government specifications.

CTC *ALL-SET* Terminal Boards, Custom-Built Boards and many other CTC *Guaranteed Components* are described and illustrated in our big new catalog #300. Send for your copy today.




*Custom or Standard*
*The Guaranteed*
*Components*

CAMBRIDGE THERMIONIC CORP.
456 Concord Ave., Cambridge 38, Mass.

# BETTER RECEPTION

## with ACME ELECTRIC TRANSFORMERS

The definitely better reception of sets powered by Acme Electric transformers, is perceptible to the eye and audible to the ear. This better performance can well be a major sales feature in a competitive market. Our engineering department will assist you in all your transformer needs.

**ACME ELECTRIC CORPORATION**
**4410 Water St. Cuba, N.Y.**

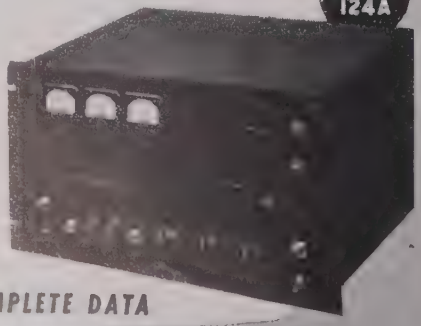
Acme ACME Electric
TRANSFORMERS



# *New* WIDE-RANGE POWER OSCILLATOR

*Designed for measurements and tests in the 300 to 2500 mc range.* The AIL Type 124A Power Oscillator unit consists of a grid separation coaxial oscillator employing a 2C38 disc seal triode, an audio oscillator and modulator section, and a self-contained power supply for operation from 115 volts at 50-60 cps.

AIL TYPE 124A



**POWER OUTPUT**
300 mc – 10 w
600 mc – 20 w
1200 mc – 10 w
2500 mc – 2.5 w

**SEND FOR COMPLETE DATA**

*Airborne Instruments Laboratory*, INC.
160 OLD COUNTRY ROAD • MINEOLA, N.Y.

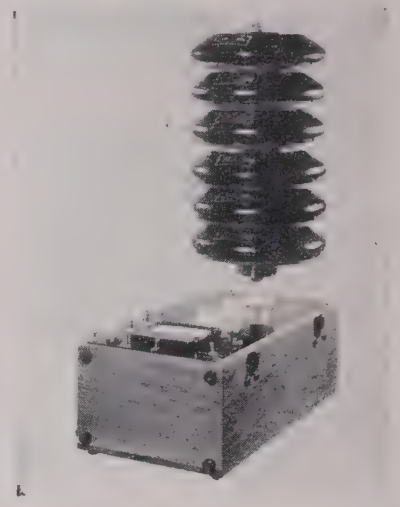

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 57A)*

## Kilovoltmeter Range Extension Device

A method, which does not require any internal meter changes, for extending the range of portable kilovoltmeters of **Shallcross Mfg. Co.,** 520 Pusey Ave., Collingdale, Pa., has been devised.



A fitting is attached to the highest-range binding post supporting from 1 to 6 Shallcross #505 Corona resistors, increasing the range as desired.

When a meter movement with full-scale current range of 1 ma is used, each resistor added increases the range by 5 kv.

## Audio Sweep Generator

A new automatic audio sweep generator, with a frequency range from 25 cps to 32 kc, has just been announced by **Clough Brengle Co.,** 6014 Broadway, Chicago 40, Ill.

Within the range described, the automatic sweep may be adjusted to any spread from 500 cps to 10 kc, or it may be operated manually.

The manufacturer claims that distortion is less than 0.5 per cent. Sweep calibration is linear, and adjustable from 2 to 10 sweeps per second. Panel calibration is direct on a 17-inch Verni-Vider dial.

Complete data is available on request of Bulletin 27A.

## Heterodyne Eliminator

Described as type MCL-4 Signal Splitter, a heterodyne eliminator has been de-

*(Continued on page 59A)*

YOU CAN TELL THE QUALITY OF THE PLUG BY THE EQUIPMENT IT CONNECTS

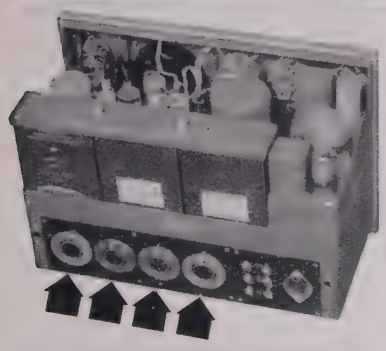
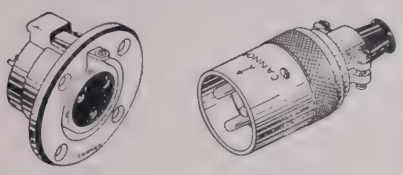


PHOTO COURTESY COLLINS RADIO, CEDAR RAPIDS, IOWA

*REMOTE AMPLIFIER (rear view) Type 12Z made by Collins. Four flush mounted P-13 Receptacles indicated by arrows. Complete catalog number of the four connectors: P3-13. Socket inserts carry three 30-amp. contacts.*

TYPE "P" SERIES



**P3-13**
Receptacle
Socket Contacts

**P3-CG-12S**
Mating Plug
Pin Contacts

Type "P" Series of multi-contact electric connectors has been used for years by broadcasting stations and in better public address systems. The series comprises 3 basic plug types and 4 receptacles, including the single gang and two gang wall receptacles. The six insert arrangements start with two 30-amp contacts and continue with 3, 4, 5, and 6. The P8- insert has eight 15-amp contacts.

*Available through more than 250 distributors, including such well known firms as Radio Specialties in Los Angeles; Henry O. Berman in Baltimore; Gifford Brown in Des Moines; United Radio in Portland; Houston Radio Supply in Houston, Texas; Interstate Dist. in Wichita, etc.*

**For complete engineering information, ask for "PO-248" Bulletin.**

SINCE 1915
CANNON ELECTRIC
CANNON ELECTRIC Development Company

**3209 HUMBOLDT ST., LOS ANGELES 31, CALIF.**

**IN CANADA & BRITISH EMPIRE:**
CANNON ELECTRIC CO., LTD., TORONTO 13, ONT.

**WORLD EXPORT (Excepting British Empire):**
FRAZAR & HANSEN, 301 CLAY ST., SAN FRANCISCO

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 58A)*

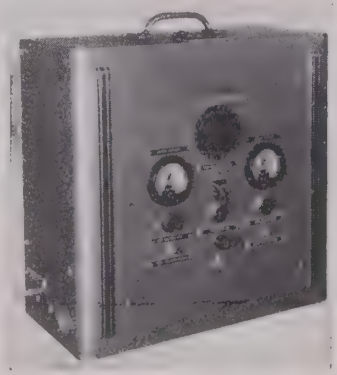
veloped for commercial purposes by **J. L. A. McLaughlin**, P.O. Box 529, La Jolla, Calif.

Intended for use with communications receivers having an if of approximately 455 kc, the MCL-4 has off frequency interference attenuation approximately 100 db down at 1.5 kc removed from carrier or telephone reception.

Approximately 2 watts output power are available for telephone reception; 4 watts output for CW. Line and speaker are provided with 500-ohm and 5,000-ohm terminals. Power supply is 105 to 125 volts, 60 cps, self-contained.

## Reversible Polarity DC Power Supply

The Model 203, 0- to 30-kv dc power supply with reversible polarity, is being produced by **Beta Electric Corp.**, 1762 Third Ave., New York 29, N. Y



The output is variac-controlled; a kilovoltmeter is included on the panel to indicate its magnitude. Voltage is continuously variable from 0 to 30 kv. Current rating is 2 ma maximum (determined by rectifier rating). Approximately 300 microamperes at 30 kv.

Input is 117 volts, 50 to 60 cps, 225 volt-amperes maximum.

## Microwave Pulse Amplifier

A new wide-band amplifier designed for amplification of microwave pulses has been introduced by **Hewlett-Packard Co.**, 395 Page Mill Rd., Palo Alto, Calif.

Described as -hp- 460A, this amplifier has a pulse rise time of 0.003 microsecond, and provides a gain of 20 db. Five instruments may be cascaded to provide additional gain.

When used in conjunction with -hp- 410A vacuum-tube voltmeter, the -hp- 460A increases voltmeter sensitivity 10 times at frequencies up to 200 Mc. This makes reading of voltages as low as 0.01 volts possible.

## Television Tube Improvement

An improved line of cathode-ray tbesu of the bent gun type utilizing a single ion-trap magnet has been developed by the Tube Div., **Allen B. DuMont Labs., Inc.**, 2 Main Ave., Passaic, N. J.

*(Continued on page 60A)*

Each unit of every JOHNSON antenna phasing system is individually designed and built to meet the requirements of the installation. Features desired by your chief engineer are incorporated and the design is approved by consultant prior to production.

Careful selection of components to provide adequate safety factor, combined with expert workmanship and advanced engineering assure excellent performance.

Control of phase shift in each leg of the circuit and control of power division among towers from the front panel are standard features.

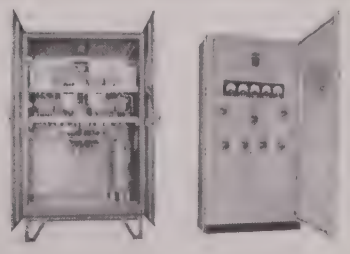
**POWER RATINGS 1 TO 50 KW**

JOHNSON, for many years a leading supplier of antenna phasing equipment, manufactures units with power ratings from 1 to 50 kw. Standard, as well as custom cabinets to match those of the well known transmitter manufacturers and virtually all the radio frequency components are made right in the JOHNSON plant. Non-standard components frequently required are made to suit particular applications.

This versatility of manufacturing to meet individual circuit design permits "custom work"—at standard price!

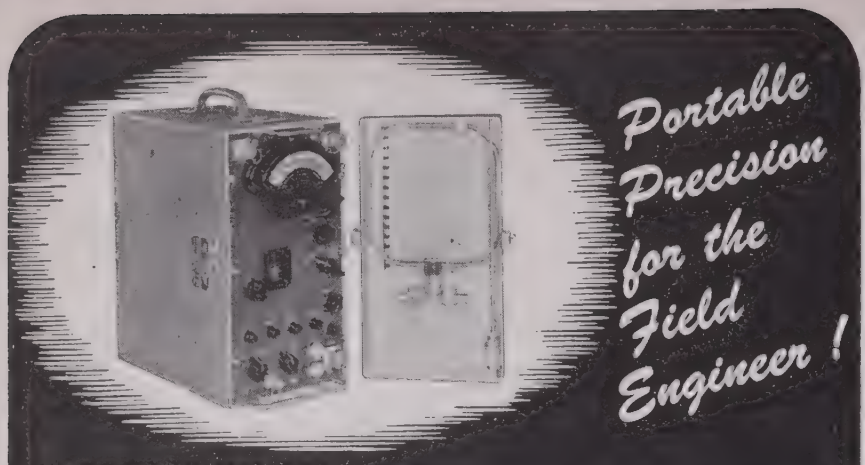
Additional phasing equipment accessories available from JOHNSON include:

- **Tower Sampling Transformers**
- **Tower Lighting Chokes and Filters**
- **Remote Metering Equipment**
- **Sampling Loops**
- **Isolation Transformers**
- **Concentric Line**



*Typical Johnson Antenna Phasing Equipment*

JOHNSON
E. F. JOHNSON CO., WASECA, MINN.



Portable Precision for the Field Engineer!

**STODDART NM-20A**
**RADIO INTERFERENCE AND FIELD INTENSITY METER**

- A portable unit that you can DEPEND upon! Designed especially to withstand the rigors of all-weather field operation and yet provide reliable performance.
- Measures FIELD INTENSITIES of radio signals and r.f. disturbances using either a rod antenna or a rotatable loop antenna.
- May be used as a two-terminal r.f. voltmeter (balanced or unbalanced), frequency selective over the CONTINUOUS RANGE 150 kc to 25 mc.
- ONE MICROVOLT SENSITIVITY as a two-terminal voltmeter; 2 microvolts-per-meter using rod antenna.
- Operates from self-contained dry batteries or external A.C. power unit providing well-regulated filament and plate supplies.

Write for complete technical data

**STODDART AIRCRAFT RADIO CO.**

Main office and plant:
6644 Santa Monica Blvd.
Hollywood 38, Calif.
Phone: Hillside 9294

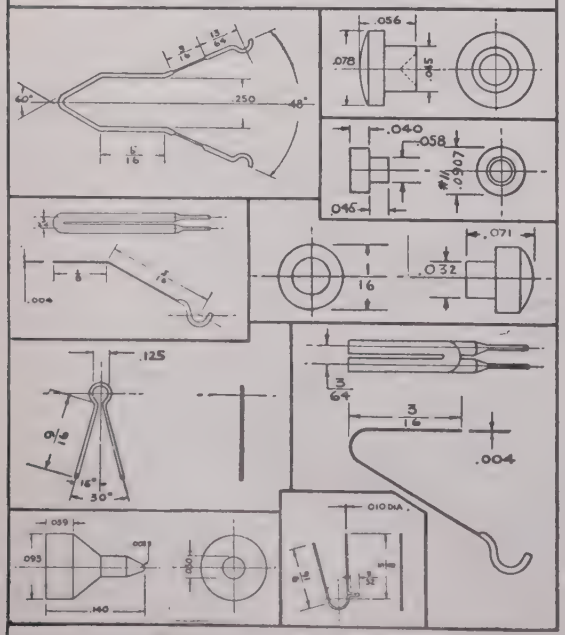
8-247 General Motors Bldg.
Detroit 2, Michigan
Phone: Trinity 1-9260

1346 Connecticut Ave.
duPont Circle Bldg.
Washington 6, D. C.
Phone: Hudson 7313



**EACH SOLVED A SPECIAL PROBLEM**

**HEADED AND FORMED WIRE CONTACTS**



**YET these are "STANDARD" NEY PRECIOUS METAL COMPONENTS**

Chart shows form and overall dimensions of a few of the many types of contacts made from Ney Precious Metal Alloys for brush or wiping contact applications. Full technical and test data are available on request. Other Ney Precious Metal Alloys have solved many special industrial application problems. Consult us freely without obligation.

*Write or phone* (HARTFORD 2-4271) *our Research Department.*

**THE J. M. NEY COMPANY**
171 ELM STREET • HARTFORD 1, CONN.
SPECIALISTS IN PRECIOUS METAL METALLURGY SINCE 1812

NEY GOLD


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

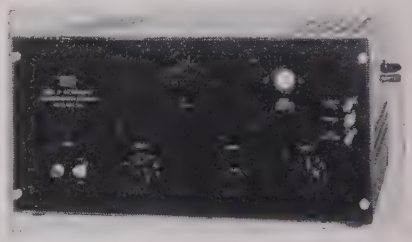
*(Continued from page 59A)*

The manufacturer states that this type of ion-trap design eliminates ion-spot blemishes, and since it bends the beam only once, results in an undistorted spot.

The new types 12RP4 and 15DP4 replace respectively types 12JP4 and 15AP4. These tubes serve as direct replacements except for the single beam-bending magnet which may be added at low cost.

## New Model Oscillator

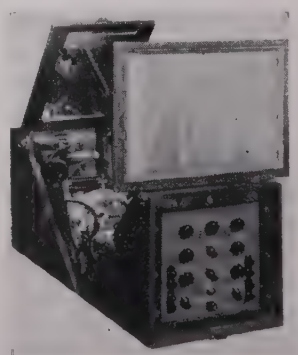
A new oscillator, Model M, with a continuously variable frequency from 0.25 cps to 120 kc has been developed by **Southwestern Industrial Electronic Co.**, 2831 Post Oak Rd., Houston 19, Texas.



Two positions are provided on the range selector switch for fixed frequencies which are determined by units which plug into the central tuning assembly. Plug-in units may be obtained for frequencies as low as 0.1 cps. Special oscillators which are modified slightly to allow operation with good wave form down to 0.1 cps can be obtained, but their dynamic characteristics are not as good as the standard model, because a longer time is required for the level to stabilize after a frequency change has been made.

## Portable Projection Oscilloscope

A new Model 701, portable oscilloscope employing the "Norelco" projection system with a 16×12 inch screen, has been developed by **Beta Electric Corp.**, 1762 Third Ave., New York 29, N. Y.



Very useful for educational and demonstrative purposes, the Model 701 when closed is a cabinet 13 inches wide, 16 inches high, and 19 inches deep, weighing 60 lbs. with the screen inside the case.

Provisions are made for external 60 cps, or internal sweep synchronization; 6.3

*(Continued on page 62A)*

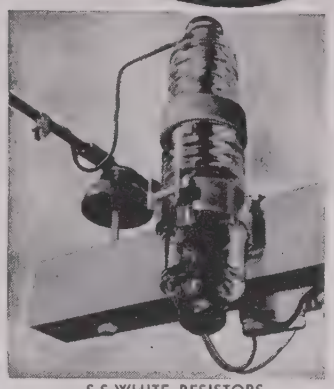
# S·S·White MOLDED RESISTORS

The "All-Weather" Resistors

## ARE USED IN HIGH VOLTAGE "HIPOT" COUPLERS

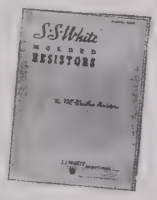
S.S.White resistors are connected in series to permit a current flow to ground, when the "Hipot" Coupler is used to measure or to synchronize voltage of high voltage lines.

Canadian Line Materials, Ltd.—maker of "Hipot" Couplers and other transmission, distribution and lighting equipment —says—"We have always found S.S. White resistors of the highest quality." This checks with the experience of the many other producers of electrical and electronic equipment who use S.S.White resistors.



WRITE FOR BULLETIN 4906

It gives details of S.S.White Resistors including construction, characteristics, dimensions, etc. Copy with price list on request.




S.S.WHITE RESISTORS are of particular interest to all who need resistors with *low noise level* and *good stability* in all climates.

HIGH VALUE RANGE
10 to 10,000,000 Megohms
STANDARD RANGE
1000 Ohms to 9 Megohms

## S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.
DEPT. GR 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS AND ACCESSORIES
MOLDED PLASTICS PRODUCTS—MOLDED RESISTORS

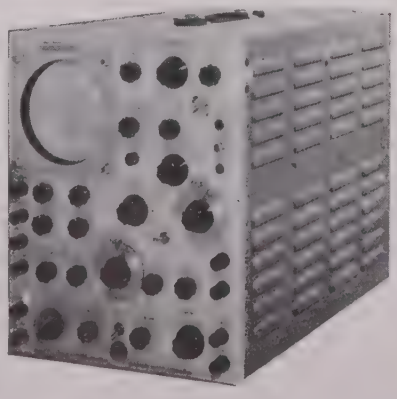
*One of America's AAAA Industrial Enterprises*

# TEKTRONIX
## DIRECT COUPLED OSCILLOSCOPE

*The **Tektronix Type 512** is a completely **new** direct coupled cathode ray oscilloscope which provides the sensitivity, band pass, sweep ranges, flexibility and dependability so necessary for precision applications.*

* * *

*Present users throughout the world—leading universities; industrial organizations; branches of armed services; physiologists; geophysicists; etc.—have come to consider the **Type 512** an indispensible instrument by virtue of its full complement of outstanding characteristics.*



**DC-2 mc. SWEEPS 3 sec-30 microsec. 5 Millivolt Sensitivity DC or AC**

*Detailed Specifications on request.*

**$950.00**
***f. o. b. Portland, Oregon***

TEKTRONIX INC.
712 S. E. HAWTHORNE BLVD. PORTLAND 14, OREGON

# Which of these books do you want to examine 10 DAYS FREE?

## 1. WAVEFORMS

**Vol. 19, MIT Rad. Lab. Series. Edited by Britton Chance, E. F. MacNichol, University of Penn.; F. C. Williams, Manchester University; V. W. Hughes, Columbia University; and D. Sayre, Alabama Polytechnic Institute. 776 pages, illustrated, $10.00**

A detailed description of the generation and use of precisely controlled voltages and currents, introducing methods of wave shaping by linear circuit elements and negative feedback amplifiers The properties of vacuum tubes as non-linear circuit elements and their application to waveform manipulation are presented in detail.

## 2. VACUUM TUBE AMPLIFIERS

**Vol. 18, MIT Rad. Lab. Series. Edited by George E. Valley, Jr., M.I.T.; and Henry Wallman, M.I.T. 733 pages, illustrated, $10.00**

Here is a complete analysis of important types of amplifiers together with their design principles and constructional techniques. The amplifiers discussed provide special characteristics such as very high gain, large bandwidth, or precise response.

## 3. COMPONENTS HANDBOOK

**Vol. 17, MIT Rad. Lab. Series. Edited by John F. Blackburn, M.I.T. 613 pages, illustrated, $8.00**

This book codifies information on the properties and characteristics of most electronic components. The first part lists fixed components such as wires, cables, resistors, etc.; the second deals with electromechanical devices, and the third section is devoted to vacuum tubes and cathode ray tubes.

## 4. ULTRASONICS

**By Benson Carlin, Hillyer Instrument Company; formerly Product Research Supervisor, Sperry Products; 264 pages, 162 illustrations, $5.00**

Here is the first engineering consideration of the ultrasonic field . . . the theory plus practical information never before published! This new book reviews electronic considerations and outlines of circuits. Mechanical and electrical design and construction techniques of ultrasonic systems are included.

It brings you valuable information on: material testing, agitation, ultrasonic transducers, ultrasonic systems. It explains clearly the characteristics of ultrasonic waves that are important in practical applications: curves, waves, and complex waves; Fourier's theorem, wave trains and the law of angular transmission; the ways ultrasonic waves may be produced, and the electromechanical converting systems.

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Send me book(s) corresponding to numbers encircled below for 10 days' examination on approval. In 10 days I will remit cost of book(s) I keep, plus a few cents for delivery, and return unwanted book(s) postpaid. (We pay for delivery if you remit with this coupon; same return privilege.)

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This offer applies to U. S. only

*Crystals for the Critical*

**EVERYTHING YOU WANT IN "STABILIZED" CRYSTALS**

High quality—quick delivery—modest cost! All three are yours when you use James Knights Co. "Stabilized" crystals.

Whether you wish standard crystals, or crystals built to your exact specifications, The James Knights Co. is equipped to supply you promptly.

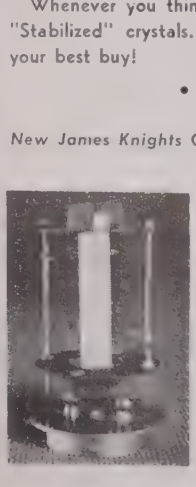
A special production system is maintained to effect greater savings for you on short run jobs.

The James Knights Co. fabricates a complete line of "Stabilized" crystals to meet every need —precision made by the most modern methods and equipment.

Whenever you think of crystals, think of JK "Stabilized" crystals. They're your best bet—your best buy!

• • •

*New James Knights Co. Catalog On Request*



A tube research laboratory needed a 19 kc crystal to use as a standard. The James Knights Company delivered one in hurry. A partially assembled H18T hermetically sealed unit on 19 kc is shown at the left. The James Knights Company does many kinds of special work for exacting customers every day.

**The JAMES KNIGHTS Co.**

SANDWICH, ILLINOIS

JK

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 60A)*

volts ac signal is available from binding posts.

Vertical deflection is approximately 60 millivolts rms per inch, or 0.6 volt full scale. Horizontal deflection is approximately 0.65 volt rms per inch, or 1 volt full scale.

## New Type Permanent Magnet Materials

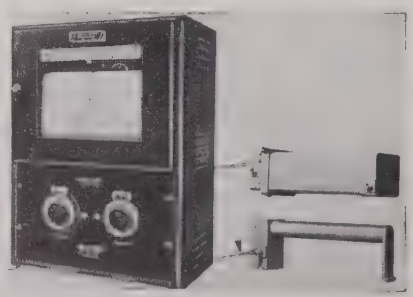
Two new types of materials for the fabrication of permanent magnets, Alnico 5 DG (directional grain), and Alnico 7, are announced by **Chemical Dept., General Electric Co.,** Pittsfield, Mass.

A change in the manufacturing process causes the crystal structure of the magnets to be aligned in the direction of magnetization. It is claimed, as a result of this, that smaller magnets may now be used to perform as larger magnets formerly did; and, that Alnico 5 DG will provide the highest external energy and residual induction of any permanent magnet material known today.

The other product, Alnico 7, has also been developed specifically for applications where a high demagnetization force is present such as in motors, generators, and variable air gap devices. This new magnet shows a higher coercive force than any other grade of Alnico.

## Beta Gauge for Industrial Applications

The Model SM-2, the first of a series of industrial measuring and control instruments using the isotope Strontium-90 as a source of radiation is announced by **Tracerlab, Inc.,** 55 Oliver St., Boston 10, Mass.



The sheet material to be measured is interposed between the source and the detector and a part of the radiation is absorbed by the sheet material in proportion to its weight per unit area. Weight per unit area or thickness is read on a properly calibrated recorder connected to the detector. The recorder scale can be calibrated in terms of a plus or minus deviation from specifications or as an absolute thickness or weight reading.

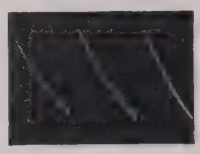
One of the advantages of these gauges is the fact that no physical contact is made with the material being measured, causing no marking of delicate or easily marred surfaces, as is the case with mechanical and other contacting gauges.

*(Continued on page 63A)*

***In only* 1 SECOND!**

**COMPLETE AUDIO WAVEFORM ANALYSIS *with the***

**AP-1 PANORAMIC SONIC ANALYZER**



Oscillograph of waveform to be analyzed

Panoramic Sonic Analysis of the same wave

**Provides the very utmost in *speed, simplicity* and *directness* of complex waveform analysis. In only one second the AP-1 *automatically* separates and measures the frequency and amplitude of wave components between 40 and 20,000 cps. Optimum frequency resolution is maintained throughout the entire frequency range. Measures components down to 0.1%.**

- **Direct Reading**
- **Logarithmic Frequency Scale**
- **Linear and Two Decade Log Voltage Scales**
- **Input voltage range 10,000,000:1**

**AP-1 is THE answer for practical investigations of waveforms which vary in a random manner or while operating or design constants are changed. If your problem is measurement of harmonics, high frequency vibration, noise, intermodulation, acoustic or other sonic phenomena, investigate the overall advantages offered by AP-1.**

***Write NOW for complete specifications, price and delivery.***

PANORAMIC RADIO PRODUCTS

SOUTH SECOND AVE MOUNT VERNON

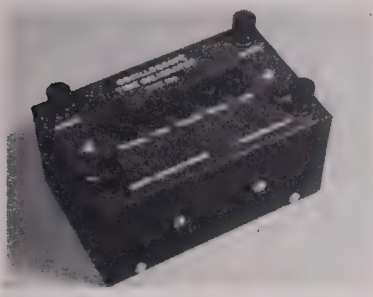
# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 62A)*

## Oscilloscope Time Calibrator

An instrument for measurement of elapsed time between any two points on the oscilloscope trace is being manufactured by **Owen Laboratories**, 9130 Orion St., San Fernando, Calif.



Designated as the Type 160, this accessory is inserted in the lead from signal source to the input, and allows either the signal to be observed or places time markers along the sweep. These markers appear as the crests of a damped sine wave, with a frequency of 1, 10, or 100 kc, or 1 Mc. Thus a choice of markers having intervals of 1 millisecond, 100 microseconds, 10 microseconds, or 1 microsecond is possible.

## New Socket-Turrets

A new terminal structure on which the circuit components associated with a vacuum tube may be connected directly at the socket, has been designed by **Vector Electronic Co.** 1101 Riverside Dr., Los Angeles 31, Calif.

By this means sub-assemblies are readily formed and these can be installed with a minimum of connections, thus simplifying the construction of electronic equipment.

Stray capacitance is generally reduced since the number and length of circuit leads is minimized. By the use of space under the socket which is usually wasted, a compact arrangement can be made. While Socket-Turrets are advantageous for experimental work, they also make possible may economies in production. These mountings are supplied in a variety of sizes and styles having octal, loctal, miniature, or noval sockets of standard design.

*(Continued on page 64A)*


# KLYSTRON POWER SUPPLY

*MODEL 910*

4 Section, Rack Mounted Unit Supplies All Voltage and Current Requirements for Most Types of Klystrons.

**OUTPUTS**

**Beam Supply**
250 to 3000 V.D.C.
0 to 300 ma.
10 mv. ripple
Regulated
Continuously Variable

**Control Electrode Supply**
0 to —300 V.D.C.
0 to 1 ma.
0 to 175 V.D.C.
0 to 30 ma.
15 mv. ripple
Regulated
Continuously Variable

**Reflector Supply**
—50 to —1500 V.D.C.
0 to 1 ma.
10 mv. ripple
Regulated
Continuously Variable

**Filament Supply**
0 to 10 V.A.C.
0 to 3 A center tapped
Continuously Variable

All sections insulated for 5000 V.D.C.
All Outputs Metered for Both Voltage and Current
Time Delay Relay—Interlock

*Write for Bulletin 910 for Complete Description and Price.*

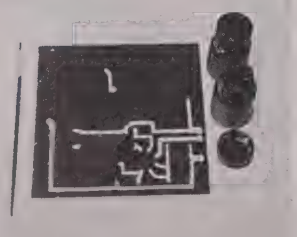
**FURST ELECTRONICS**
14 S. Jefferson St., Chicago 6, Ill.

FREE: 32,000 RESISTORS*
These Kits are in use by industrial, design, and research labs.; colleges; trade schools; amateurs.

**Printed Circuit Kits**

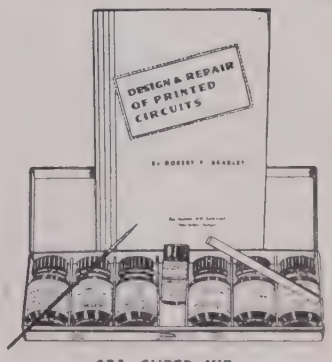
YOU CAN REDUCE COSTS ON YOUR PRESENT PRODUCTS
with the aid of Conducting, Resistance, and Magnetic Coatings.

PRINTED CIRCUITS can be used in EVERY branch of electricity



HAND PAINTED CIRCUIT

You do not have to switch completely to printed circuits to realize part of their savings. Your present product designs can benefit from brush or spray-applied conducting and resistance coatings. A few dabs or short painted or sprayed lines may save you pennies and dimes on every unit. Current uses are for shielding, elimination of resistors and wires, grounding of static charges, increasing coil and conductor inductance, and many others.




S21 SUPER KIT

The S21, Super Kit, is a complete experimental-printed-circuit-paint laboratory. Contains Silver Conducting Paint; Copper Conducting Paint; Low, Medium, and High Resistance Paints; Solvent; and Lacquer. Manual "Design and Repair of Printed Circuits" included free with each Kit.

From your distributor or our factory only $7.27.

*One Kit contains the equivalent of 33,000 ¼-watt resistors.

DO THIS:
1. Order one of our convenient S21 Kits of air-drying conducting and resistance paints.
2. Use it to simplify your circuits or to make complete experimental printed circuits.
3. Tell us what kind of paint you will need in quantity. We will supply it.

MICROCIRCUITS COMPANY Dept. 10K New Buffalo, Michigan

# FM SIGNAL GENERATOR

*TYPE 202-B*

**54-216 Megacycles**

*Specifications:*

**RF RANGES: 54-108, 108-216 mc. ±0.5% accuracy. Also covers 0.4 mc. to 25 mc. with accessory 203-B Univerter.**

**VERNIER DIAL: 24:1 gear ratio with main frequency dial.**

**FREQUENCY DEVIATION RANGES: 0-24 kc., 0-80 kc., 0-240 kc.**

**AMPLITUDE MODULATION: Continuously variable 0-50%, calibrated at 30% and 50% points.**

**MODULATING OSCILLATOR: Eight internal modulating frequencies, from 50 cycles to 15 kc., available for FM or AM.**

**RF OUTPUT VOLTAGE: 0.2 volt to 0.1 microvolt. Output impedance 26.5 ohms.**

**FM DISTORTION: Less than 2% at 75 kc. deviation.**

**SPURIOUS RF OUTPUT: All spurious RF voltages 30 db or more below fundamental.**

**AVAILABLE AS AN ACCESSORY**
is the 203-B Univerter, a unity gain frequency converter, which in combination with the 202-B instrument provides additional coverage of from 0.4 to 25 megacycles.

*Write for Catalog G*

DESIGNERS AND MANUFACTURERS OF
THE Q METER • QX CHECKER
FREQUENCY MODULATED SIGNAL GENERATOR
BEAT FREQUENCY GENERATOR
AND OTHER DIRECT READING INSTRUMENTS

**BOONTON RADIO Corporation**
BOONTON · N·J · U·S·A

# 200 MC BAND WIDTH

## 40 db GAIN

## MODEL 204 WIDE BAND CHAIN AMPLIFIER

**Band Width: 100 KC to 200 MC. Gain: 40 db.**
**Impedance: 200 ohms. Rise time: .003 usec.**
**With the Model 204:** transients, pulses and other high frequency voltages can now be amplified with the convenience of audio amplifiers.
**With the Model 204:** vacuum tube voltmeters and oscilloscopes are 100 times more sensitive.
**With the Model 204:** the output of signal, sweep and pulse generators and crystal and mercury delay lines are 100 times greater.
**With the Model 204:** television signals are 100 times stronger.

*Other Wide Band Chain Amplifiers available:*
**Model 200A — 10 db gain. Model 202 — 20 db gain.**
Makers of chain amplifiers, temperature controls, variable electronic filters, high frequency probes, and power supplies.

*Write for Bulletin 204-1.*

**SKL SPENCER-KENNEDY LABORATORIES, INC.**
186 MASSACHUSETTS AVE., CAMBRIDGE 39, MASS.


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 63A)*

• • •On a condensed general catalog describing a complete line of products and components of **James Millen Mfg. Co., Inc.,** 150 Exchange St., Malden, Mass.

• • •A 26-page booklet entitled "Inco Nickel Alloys for Electronic Uses" has been made available by **International Nickel Co., Inc.,** 67 Wall St., New York 5. N. Y.

• • •On a bulletin describing four types of soldering guns with interchangeable tips, from **Weller Mfg. Co.,** 808 Packer St., Easton, Pa.

• • •A new 50-page catalog in color, describing production methods, many measuring instruments, and a list of representatives and repair stations may be obtained by writing to **Simpson Electric Co.,** 5200-18 W. Kinzie St., Chicago 44, Ill.

• • •A measurement manual, available to chief engineers of radio stations, to assist in making FCC required station performance measurements for FM and AM, may be obtained from **Hewlett-Packard Co.,** 395 Page Mill Rd., Palo Alto, Calif.

• • •A catalog, #OP-AR50, describing a heavy-duty spash-proof switch with a "plate" type actuator, rated at 15 amperes, 125, 250, or 460 volts ac, single-pole, double-throw, may be obtained from **Micro Switch Corp.,** 11 W. Spring St., Freeport, Ill.

## TV Power Supply

A lightweight power supply capable of providing a source of regulated dc at loads from 200 to 300-ma has been designed by the **Television Section, RCA Victor Div., Radio Corp. of America,** Camden, N. J.

Suitable for broadcast, laboratory, industrial, and communications applications, the type TY-25A is adapted for use as either a rack-mounted, or as illustrated, a portable unit.

The output is adjustable between 260 and 290 volts, with variations of less than 0.5 per cent from minimum to maximum load. The ac ripple is less than 0.01 per cent from peak-to-peak. Power requirement is 120 volts, 60 cps, 300 watts.

*(Continued on page 65A)*

**STURDY!**

**JOHNSON BANANA SPRING PLUGS AND JACKS**

Studs extend full length of springs for added support. High grade nickel plated brass screw machine parts with accurate threads and milled nuts.

All plugs can be furnished with nickel, cadmium or silver plating if required.

JOHNSON also manufactures spring sleeve types, removable round head tip jacks, molded round head tip jacks, insulated combination jacks, metal head tip jacks, twin tip jacks and shorting type twin tip jacks.

See them at your JOHNSON Dealer . . . notice their high quality . . excellent design!

**E. F. JOHNSON CO.**
WASECA, MINNESOTA



*A.R.C.'s VHF Communication and Navigation Equipment is a*

**REVELATION**

Get static-free communication and the added reliability of omni range navigation with A. R. C.'s Type 17 2-way VHF Communication and Type 15B Omni Range Navigation Equipment. With the 15B tuned to VHF omni stations, you fly directly in less time. You can receive weather broadcasts simultaneously with navigation signals —**static free!** It simplifies navigation and gives long, trouble-free life. The Type 17 adds an independent communication system for use while the 15B is providing navigational information. Installations for both single and multi-engined planes are made only by authorized agencies.

**CLEAR COMMUNICATION ON VHF**

All A.R.C. airborne equipment is Type Certificated by CAA. It is designed for reliability and performance—not to meet a price. Write for further details or name of your nearest A.R.C. representative.

**Aircraft Radio Corporation**
BOONTON, NEW JERSEY

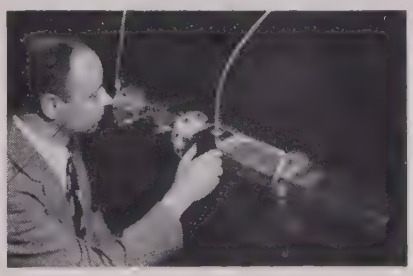

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 64A)*

## Waveguide Test Equipment

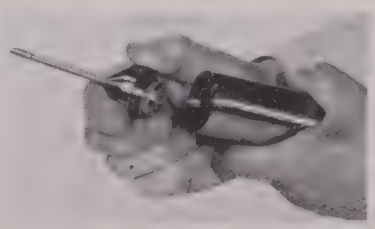
The illustrated microwave test apparatus, operating between 2,600 and 3,950 Mc, was designed and developed by **Varian Associates,** 95 Washington St., San Carlos, Calif.



On the left, the co-axial cable to waveguide transition has VSWR of less than 1.25 from 2,700 to 3,200 Mc, and a connectorless coupling accommodating RG-5/U, RG-8/U, or RG-21/U flexible co-axial cable directly, utilizing the inner conductor as the probe. Range of the variable attenuator is from 0.5 to 10 db, with power rating of 1 watt coverage, 1 kw peak.

## Improved Sound Pressure Measurement Equipment

The Model GA-1007 sound pressure measurement equipment, with the microphone permanently attached to the tip of the flexible probe, is now available from the manufacturer, **Massa Laboratories, Inc.,** 3868 Carnegie Ave., Cleveland 15, Ohio.



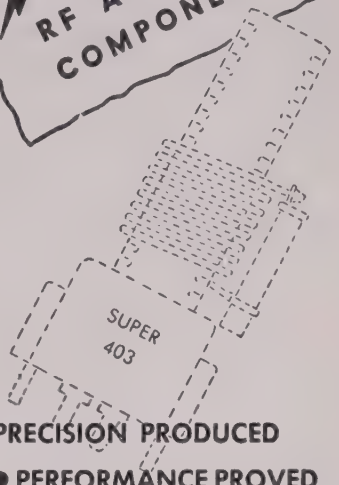
This instrument will directly measure sound pressure from a few to several million dynes/cm² in a range from 50 cps to 250 kc. The output signal is delivered by a 25-foot cable at an impedance level of 500 ohms. Extension cables have no appreciable effect on the frequency characteristic of the system.

The manufacturer further states that wave fronts whose pressure changes occur in periods of only a few microseconds are easily measured with the Model GA-1007.

*(Continued on page 68A)*


**NOTE THIS NAME**

**SUPER RF AUDIO TV COMPONENTS**

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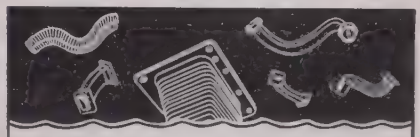

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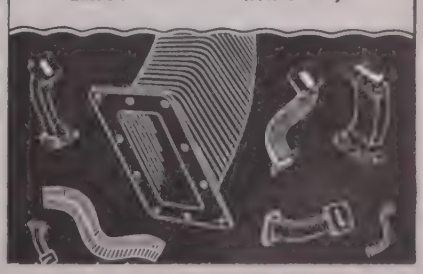
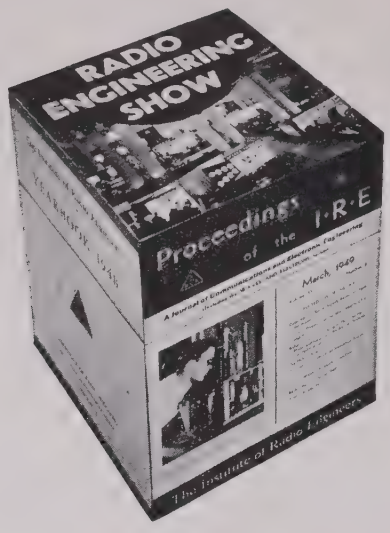


# Reaching 17,000 Radio Engineers

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Product Presentation is accomplished in the annual Radio Engineering Show to which 15,710 radio engineers came in March 1949. Here, in four days you can do more contact work, at lower cost than in any other way!

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# ACCURATE PHASING WITH T.I.C.
# METHOD OF GANGING PRECISION POTENTIOMETERS

### MECHANICAL SPECIFICATIONS

- Precision machined aluminum base and cover 2" diameter, 1" depth.
- Precision phosphor bronze bushing.
- Centerless ground stainless steel shaft.
- No set screws.
- Mechanical rotation—360°.
- Clamping method of ganging permits individual adjustment of angular position.
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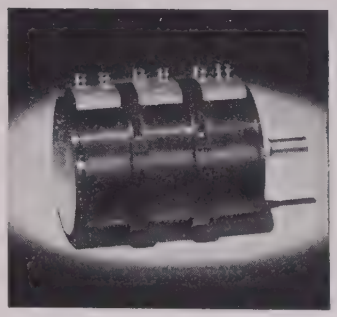

(3 gang RV-2)

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- Winding—both linear to 0.2% and nonlinear to 1% accuracies.
- Paliney contact to winding; two-brush rotor take-off assembly with precious metal contacts.
- High, uniform resolution provided by our method of winding non-linear resistances.
- Electrical rotation maximum 320°.
- All soldered connections (except sliding contacts.)

*Write today for bulletins on other T.I.C. products: Z-Angle Meter . . . R.F. Z Angle Meter . . . R-F Power Oscillator . . . Translatory Variable Resistors . . . Slide Wire Resistance Boxes . . . Phase Angle Meter.*

This general line of precision potentiometers was developed in collaboration with the Fire Control Section of the Glenn L. Martin Company.

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- MEASURES radiated and conducted signals, including pulse or random interference.
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- SENSITIVITY — Field strength using rod antennas one microvolt-per-meter to 2 volts-per-meter. Field strength using shielded loop antennas 10 microvolts-per-meter to 100 volts-per-meter. As a two-terminal voltmeter, either balanced or unbalanced, one microvolt to one volt.
- READS directly in microvolts and db.
- A.C. POWER SUPPLY REQUIREMENTS 105 to 125 volts or 210 to 250 volts A.C. Single phase source may be ANY FREQUENCY BETWEEN 50 CPS AND 1600 CPS. No shock hazard.
- GRAPHIC RECORDER included with versatile complement of accessories.

Write for complete technical data

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Phone: Hillside 9294

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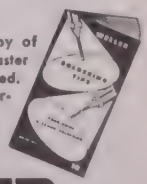
Phone: Hudson 7313

**You can do every kind of soldering with this new 250 watt Weller Gun. Power-packed, it handles heavy work with ease—yet the compact, lightweight design makes it equally suited for delicate soldering and getting into tight spots.**

**Pull the trigger switch and you solder. Release the trigger, and off goes the heat—automatically. No wasted time. No wasted current. No need to unplug the gun between jobs. 'Over and under' position of terminals provides greater visibility with built-in spotlight. Extra 5¼" length and new RIGID-TIP mean real soldering efficiency.**

**Chisel-shape RIGID-TIP offers more soldering area for faster heat transfer, and new design gives bracing action for heavy jobs. Here you get features not found in any other soldering tool . . . advantages that save hours and dollars. Your Weller Gun pays for itself in a few months. Order from your distributor or write for bulletin direct.**

SOLDERING TIPS—get your copy of the new Weller guide to easier, faster soldering—20 pages fully illustrated. Price 10c at your distributor, or order direct.



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# THE MU-BETA EFFECT CALCULATOR

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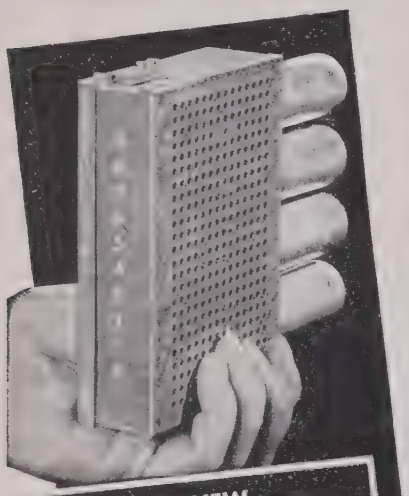

THE NEW BERKELEY MODEL 700 DECIMAL COUNTING UNIT

This unique packaged component is *easily built into* your apparatus. It has *true decimal reading*, and simple binary circuit with reliable *automatic interpolation*. Miniature size. Moderate price. Immediate shipment.

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# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 65A)*

## New Mutual Conductance Tube Tester

A portable tube tester, Model 600, with dynamic mutual conductance circuits for accurate test of radio or TV tubes, has been designed by **Hickok Electrical Instrument Co.**, 10551 Dupont Ave., Cleveland 8, Ohio.

Scale readings are directly in micromhos, with ranges of 0–3,000–6,000–15,000 micromhos.

The Model 600 is housed in a portable case, $7\frac{1}{2}$ inches by $11\frac{3}{4}$ inches by $16\frac{3}{4}$ inches. Weight, 15 lbs. For complete information, write H. D. Johnson at Hickok.


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## New Freed Instruments

Introduced for electronic laboratory use, the **Freed Transformer Co.**, 1718-36 Weirfield St., Brooklyn 27, N. Y. announces a new power supply and a null detector voltmeter.

The A.C. Power Supply Freed is a laboratory instrument with a continuously variable output from .1 volt to 100 volts with variable 60 cycles supply. It is illustrated here.

The #1210 Null Detector and Vacuum Tube Voltmeter is presented as precision equipment designed for a.c. Bridge measurements. It provides simultaneous measurement of the voltage across the unknown and the balance of the bridge. According to the manufacturer, sensitivity to .1, 1, 10, 100 volts and the Input Impedance is 50 megohms shunted by 20 mmgd. frequency range is 20 cycles to 20,000 cycles. Null detector gain is 94 Db. Selective circuits for 60 cycles, 400 cycles and 1000 cycles. Frequency range is 20 cycles to 30,000 cycles.

## Exhibit Reservations Early and Heavy In 1950 Show

183 exhibit reservations have already been made and assigned in the 1950 Radio Engineering Show to be held in Grand Central Palace, March 6–9, in conjunction with the IRE National Convention.

Acting surprisingly fast on the first industry announcement, most of the "famous regulars" who have been in every show since IRE moved to Grand Central Palace, have taken their usual space.

But 33 new companies have been quick to reserve space too. Special interest has been shown in the combination booths with sound demonstration theatres provided for audio exhibitors.

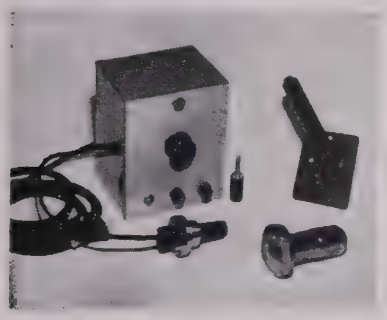
"Island Style" grouping and wider aisles on the second floor have been so well received that this floor is entirely sold out. For full information and Floor plans, write Mr. Robert Marcett, Reservations Manager, Rm. 707, 303 West 42nd Street, New York 18, N. Y.

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

## New Accessories for Electron Microscope

Three accessories permitting specialized application of the RCA electron microscope was announced by the **Scientific Instruments Section, RCA Engineering Products Dept.,** Camden, N. J.



On the left, the EMN-1 charge neutralizer designed to neutralize charges produced on diffraction specimens by the primary electron beam of the microscope. Complete with power supply which operates from a 115-volt, 50 or 60 cps-ac line, and draws approximately 60 watts, the unit consists of a heated filament which sprays a low-velocity stream of electrons into the diffraction specimen chamber.

Above right, the type EMX-1 focusing magnifier consisting of a low-power microscope, which may replace either of the viewing chamber side windows a small prism coated on the upper face with fluorescent material, and a control handle to move the prism in and out of the electron beam path permits direct viewing of the image at 150,000 magnifications.

Providing controllable intense illumination with lower beam current, the self-bias gun kit, MI-12986, lower right, makes it possible to obtain maximum resolution in studies of a wide range of specimens. It is possible, when employing the diffraction adapter, to obtain diffraction patterns of specimens. The self-bias gun is interchangeable with the zero-bias gun which is standard equipment for the type EMU electron microscope.

## Double-Pole Line Switch

A small-size (0.888 inch in diameter by 0.312 inch thick) double-pole line switch for volume, tone and other variable resistor controls has been announced by the **Stackpole Carbon Co.,** Tannery St., St. Marys, Pa. The new unit is known as Switch Type A-10, and combines design simplicity with ample-sized contacts and positive contact wiping action. Standard types are rated 1 amp at 250 volts ac-dc, or 3 amperes at 125 volts ac-dc.

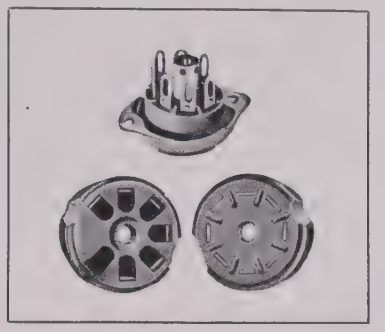
Other features include stationary contacts mounted on fibre surface phenolic material to reduce arc tracing, and a bakelite base held securely in the can.

*(Continued on page 49A)*


*Announcing*

**MYCALEX 7 Pin Miniature Tube Sockets**

For the first time a miniature tube socket of glass-bonded mica has been produced successfully by injection molding. It permits closer tolerances, low dielectric loss with high dielectric strength, high arc resistance and dimensional stability over wide humidity and temperature ranges. The technical skill and research of Mycalex Corp. of America has made it possible to produce insulating materials with extremely low loss factors at competitive prices.



Above: Complete 7 pin miniature socket.
Below: Precision moldings in MYCALEX insulation—actual size. 2 side view.

MYCALEX 410 is designed to hold closer dimensional tolerances than ceramics and with a lower loss factor than mica filled phenolics with an advantage in economy.

MYCALEX 410X is designed to compare favorably with general purpose bakelite in economy but with a loss factor of only about one-fourth of that material.

The following ratings show the difference between Mycalex 410 and Mycalex 410X miniature tube sockets.

| MYCALEX 410 (color grey) | | MYCALEX 410X (color lt. green) |
|---|---|---|
| 600 V.ac | Rated Working Voltage | 600 V.ac |
| .015 | Insulation loss factor (at 1 M.C.) | .083 |
| 1000 megohms | Insulation resistance (Minimum) | 1000 megohms |
| | Safe operating temperatures: | |
| 80° C. | Brass contacts | 80° C. |
| 375° C. | Socket body | 375° C. |

These sockets are now available, manufactured to precise specification and fully meet RMA standards. We would be glad to have our engineers consult with you on your particular design problems. Write for prices, complete data sheet and samples to:

**Mycalex Tube Socket Corporation**
"Under Exclusive License of Mycalex Corporation of America"
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*(Continued from page 40A)*

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Heiden, C. M., 429 Plymouth Dr., Syracuse, N. Y.
Rhoads, J. A., 3960 Cherrywood St., Los Angeles 43, Calif

### Transfer to Member

Ammerman, C. R., Electrical Engineering Bldg. Pennsylvania State College. State College Pa.
Blackwell, J. H., Physics Department, University of Western Ontario, London, Ont., Canada
Church, T. S., 3079-Q-34 Sandia Base Branch Albuquerque, N. Mex.
Climent, L. J., 984 Broadway, Brooklyn 21, N. Y.
Gainer, W. P., 5555 N. Bay Ridge Ave. Milawukee 11, Wis
Hansen, E. L., 224-04—93 Rd., Queens Village 8. N. Y.
Laitinen, P. O., 119 Kinship Rd., Baltimore 22. Md.
LeVine, D. J., 2 Stuyvesant Oval. New York 9. N. Y.
Mahaffey, R. F., 1304 Michigan, Alamogordo. N Mex
Moffet, J. A., 4831-1 S. 28 St., Arlington, Va
Singleton, C. M., Pan American-Grace Airways Inc. Communications Department Lima Peru
Swanson, E. H., 36 Harbour Way. Sea Cliff, L. I N. Y.
Trevey, C. B., 2555 Pierce St., Beaumont, Tex
Volz, C., 160 W Hamilton Ave., State College. Pa
Weeks, R. R., 3375 Third Ave S E., Cedar Rapids, Iowa
Wonnell, T. S., 2045 Allison St., Indianapolis, Ind

### Admission to Member

Blasingame, J. J., 337 N. Elm St., Osborn, Ohio
Cornwell, R. C., Federal Telephone and Radio Corporation, 100 Kingsland Rd. Clifton. N. J.
Davidson, A. R., 3422 Argyle Ave., Erie, Pa
Francis, C. A., 7401 Satsuma, Houston, Tex.
Hammond, L. A., 44 Lippincott Ave., Long Branch. N. J.
Holpuch, C. J., 2935 W Berteau Ave., Chicago 18 Ill.
Koppl, W., 9 St. John's Rd., Baltimore 10, Md
Kunz, L. C., Jr., Bldg. 6, General Electric Company. Electronics Park, Syracuse N Y
Luke, R. W., 171 John St., London, Ont., Canada
Nichols, W R., Box 1040, Alaska Broadcasting Company, Anchorage, Alaska
Quigley, F T., 108 E. Sixth St., Emporium, Pa.
Randolph, G. W. Bendix Radio Division, Department 63, Towson, Md
Rao, C. B., Department of Radio Technology, S. J O. Institute Bangalore, India
Scalise, L. D. 300 Lincoln Ave., Warren, Pa
Sheriff, D. R., 57 W Mira Monte. Sierra Madre. Calif.
Tavernier, G. C., 7 Rue Du Vivier, Ixelles, Bruxelles. Belgium
Vore, W. E., 420A Nimitz Ave., China Lake, Calif
Warner, M., 5 Newman St., River Plaza, Red Bank. N. J
Weinmann, R. H., 27 N Court, Roslyn Heights, L. I., N Y

**The following elections to Associate grade were approved and will be effective as of October 1, 1949:**

Althouse, J. M. 1554 S. Smithville Rd., Dayton 10, Ohio
Baron, T., 3077 Lafayette Blvd., Lincoln Park 25 Mich.
Berliner, O., 1007 N Roxbury Dr. Beverly Hills Calif
Bird, W. A., 208 E. 51 St., Brooklyn 3, N. Y
Bishop, F. L., 54 Church St Merrimac, Mass

*(Continued on page 46A)*

Cramer

TYPE TEC
TIME
DELAY
RELAY

FUNCTION

Cramer TEC Time Delay Relays provide an adjustable or fixed time delay between the closing and opening of a load circuit. Automatic reset feature restores timer to normal start position when control circuit fails or is de-energized. Also available with reverse clutch that prevents reset in case of power failure.

CONSTRUCTION

Consist of a self-starting, slow speed synchronous motor with sturdy gear train . . . an electro-magnetically operated clutch . . . a switch and switch-tripping mechanism. Complete mechanism mounted on die-cast front plate with dust protected enclosure. Dials and cases conform to standard instrument panel specifications for either flush or surface mountings. Dials equipped with progress indicators, convenient thumbscrew setting.

TIME RANGES

| Time Range | Dial Divisions | Minimum Setting | Type No. |
|---|---|---|---|
| 15 sec. | .25 sec. | .75 sec. | TEC-15S |
| 30 sec. | .5 sec. | 1.5 sec. | TEC-30S |
| 60 sec. | 1 sec. | 3 sec. | TEC-60S |
| 2 min. | 2 sec. | 6 sec. | TEC- 2M |
| 5 min. | 5 sec. | 15 sec. | TEC- 5M |
| 15 min. | 15 sec. | 45 sec. | TEC-15M |
| 30 min. | 30 sec. | 90 sec. | TEC-30M |
| 60 min. | 1 min. | 3 min. | TEC-60M |
| 3 hrs. | 5 min. | 15 min. | TEC- 3H |
| 6 hrs. | 10 min. | 30 min. | TEC- 6H |

Standard time ranges for Cramer Type TEC and TER Time Delay Relays are shown above. If your special requirement suggests variations from standard specifications, write us. For full technical description of all Cramer Time Delay Relays, send for bulletins 700C, 800E and 900D.

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# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 43A)*

## New Preamplifier

A new preamplifier, Model 130H, to equalize low frequencies and provide necessary gain for magnetic pickups is announced by **Pickering & Co.**, 308 Woods Ave., Oceanside, L. I., N. Y.

The preamplifier is self-powered, operates with any high-quality, high-input impedance amplifier, and installs by plugging in. It is said to be superior to most broadcast station equipment in its frequency response and accuracy or equalization; also, its intermodulation and harmonic distortion is said to be lower than engineering practice requires of professional equipment.

## Substitution Tester

**Oak Ridge Antenna, Div. of Video Television, Inc.**, 239 East 127 St., New York 35, N. Y. introduces the Model 101 Substitution Tester.

This compact ($5\frac{3}{4}$ inches × $3\frac{3}{4}$ inches × $2\frac{1}{4}$ inches) lightweight tester contains a range of substitute capacitors from 0.001 to 0.5 μfd, 600 volts, 30 μfd, 450 volts to 150 μfd, 150 volts, resistors from 100 ohm to 100,000 ohm 2 watt, a variable potentiometer 0–2 Mc, and a test speaker with connection to either voice, coil or transformer.

*(Continued on page 55A)*

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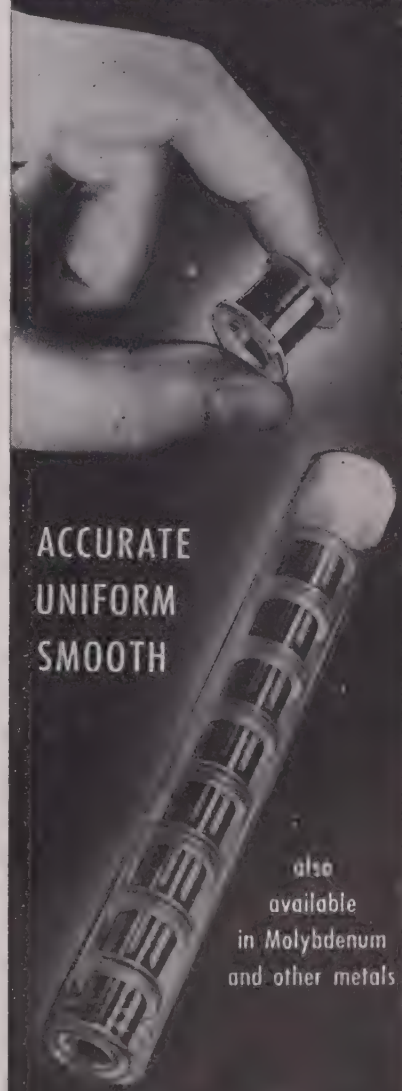

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Excellent opportunity for a man with experience in servo mechanisms and circuit theory work. Opportunity for graduate work available. Write Box 30, State College, Pennsylvania.

### DEVELOPMENT PHYSICIST ENGINEER

Experienced in theory, design and construction of attenautors, D.C. to 3 KMC, and associated test equipment, well versed in physics, chemistry and application of conductive films, operation of power tools, advanced mathematics. Write giving complete education and experience to Weinschel Engineering Co., 123 William Street, New York 7, N.Y.

### DIRECTOR OF TRAINING

Southern, G. I. approved, private vocational school desires capable man to take charge of teaching courses in radio and television. Salary $300 to $350 per month. Scholastic hours. Teaching experience preferred. Write Mr. J. D. Muse, P. O. Box 505, Atlanta, Georgia.

### MECHANICAL ENGINEERS AND DESIGNERS

Fully qualified. Accustomed to working with small electromechanical devices. Write Mr. D. A. Murray, Mount Dennis, Toronto 15, Canada.

### ELECTRONIC ENGINEER

Fully qualified. At least five years laboratory experience in circuit design and radio physics. Canadian national preferred. Write Mr. D. A. Murray, Mount Dennis, Toronto 15, Canada.

### DEVELOPMENT ENGINEERS

All grades with degrees and experience in design and development of high quality instruments for research in physics, chemistry, etc. Applicant will be required to design and develop electrical, electronic and mechanical instruments for the nuclear field. Salary commensurate with ability to produce a final working model from the idea state. Box 577.

### ELECTRONIC TECHNICIANS

For work in laboratory, assembling, wiring and testing of precision electronic design models. Applicants must have at least three years of similar experience and must be capable of producing the highest quality work. Box 577.

### ENGINEER

Wanted, new electronic ideas, company with capital and manufacturing facilities is seeking new electronic products, inventions, or ideas to expand commercial business. Liberal arrangements with inventors. Box 578.

### ENGINEERS

Electrical or Electronic engineers with experience in magnetic recording techniques and/or systems, preferably in the computer field. Box 579.

### ENGINEER

A government-supported project with a college in NYC has an opening for an experienced vacuum tube development engineer. Duties are technical-administrative, with opportunity to initiate and conduct research part-time. State qualifications and salary requirements. Box 580

### ELECTRICAL ENGINEERS

Highly interesting research and design positions are open at Army Security Agency, Washington 25, D. C., in the field of electronics for electrical engineers, grades P-3, $3727.20 per annum through P-5, $6235.20 per annum. Minimum requirements are a Master's degree or a Bachelor's degree from an accredited college or university, plus one year of professional engineering experience. All positions are permanent insofar as the Agency is concerned. Address reply to, Chief, Army Security Agency, CSGAS-61, The Pentagon, Washington 25, D.C.


# POSITIONS OPEN FOR PHYSICISTS SR. ELECTRONIC ENGINEERS

**Familiar with ultra high frequency and micro wave technique**

**Experience with electronic digital and/or analog, computer research and development program**

**Salaries commensurate with experience and ability. Excellent opportunities for qualified personnel**

**CONTACT**
**C. G. Jones, Personnel Department**
**GOODYEAR AIRCRAFT CORPORATION**
**Akron 15, Ohio**

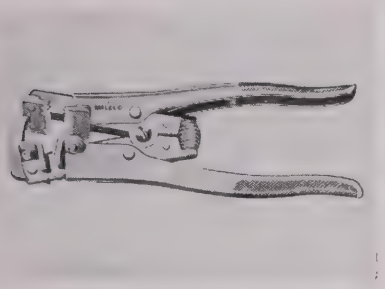
# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 49A)*

## All-Purpose Wire Stripper

A new all-purpose wire stripper has just been announced by the **Walter L. Schott Co.**, 9306 Santa Monica Blvd. Beverly Hills, Calif



The Walsco wire stripper incorporates these features: strips all wires from 16 to 22 gauge; strips 300 ohm twin lead; and has built-in wire cutter and automatic locking device which prevents crushing of wires. It is further claimed that this tool will strip insulation cleanly and quickly, yet will not nick or cut wire strands. Blades are hardened and precision-ground, and are easily replaced when dulled.

*(Continued on page 56A)*


# IT'S KINGS FOR CONNECTORS

Pictured here are some of the more widely used R. F. co-axial, U. H. F. and Pulse connectors. They are all Precision-made and Pressurized when required. Over 300 types available, most of them in stock.

**Backed by the name KINGS—the leader in the manufacture of co-axial connectors.**
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811 LEXINGTON AVE., BROOKLYN 21, N. Y.

*Manufacturers of Radar, Whip, and Aircraft antennas Microphone Plugs and Jacks.*
*Radar Assemblies, Cable Assemblies, Microwave and Special Electronic Equipment*

# WESTINGHOUSE RESEARCH in TELEVISION

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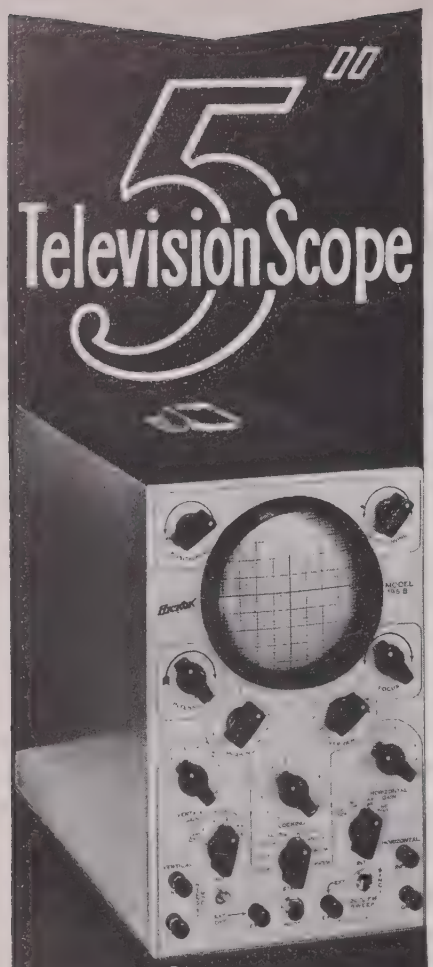
Specialists in OPTICS, ELECTRON-OPTICS, PHOSPHORS, PHOTO-SURFACES, SYSTEMS and CIRCUITS needed for an expanding program at the Westinghouse Research Laboratories, East Pittsburgh, Pa.

**For Information write:**
**Manager, Technical Employ.**
**Westinghouse Elec. Corp.**
**306 4th Ave., Pittsburgh, Pa.**

# Look It Up In Your IRE Yearbook

## *Use Its Engineering Products Listings!*

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HIGHEST PRACTICAL SENSITIVITY
.03 volts per inch.
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PHASING CONTROL
SYNUSOIDAL SWEEP
DIRECT CONNECTION TO VERTICAL PLATES AVAILABLE

Ideal for industrial and laboratory applications, and for fast accurate receiver alignment. Model 195B. Write for complete information today.

World Famous for Accuracy for 39 Years

THE HICKOK ELECTRICAL INSTRUMENT CO.
10587 Dupont Ave., Cleveland 8, Ohio

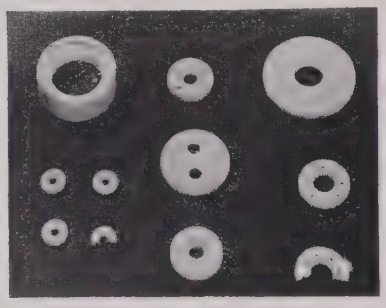

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 55A)*

## Molded Insulating Spacers and Beads

Fabrication of its new packing material "Chemlon" into electrical insulating spacers and anchor beads has been announced by the **Crane Packing Co.**, 1800 Cuyler Ave., Chicago 13, Ill. The trade name "Chemlon" represents the company's name for its line of products made by processing the plastic polytetrafluoroethylene.

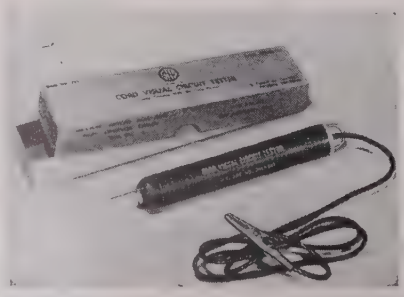


The company states that the electrical properties are low power factor and low dielectric constant; loss factor dielectric constant and dielectric strength do not vary with temperature changes below 400°F.; volume resistivity is not affected by moisture, and surface resistivity is quite high; the material is also resistant to arc exposure, as soon as the arc is extinguished, full insulation strength is restored.

Additional information about the molded insulation for high-frequency applications can be obtained from the manufacturer.

## New Circuit Tester

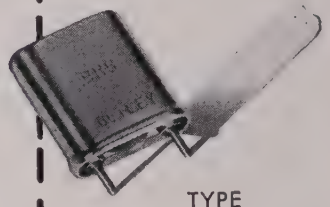
A circuit tester that is small enough to fit into the pocket or tool box has just been introduced by the **Gits Molding Corp.**, 4600 W. Huron St., Chicago 44, Ill.



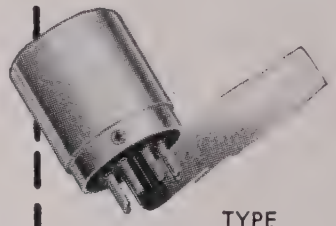
Called the "Cord Visual Circuit Tester," the product is claimed by its manufacturer to be suited for checking a wide variety of circuit applications. Using two penlight battery cells, the new instrument is designed for use on all low resistance circuits of 50 ohms and under.

*(Continued on page 57A)*


NOT "Just a Product"



TYPE BH6



TYPE TCO-1
OPER. TEMP. 75°C.
RATING 6.3V. - 5.5W

**But A COMPLETE KNOWLEDGE OF FREQUENCY CONTROL**

***Type BH6 . . .*** Miniature size crystal unit. Frequency range . . . 1 MC to 100 MC . . . Tolerances meet all commercial or military specifications . . . hermetically sealed . . . in demand where space limitations are a problem . . . precision performance based on Bliley's *complete knowledge of frequency control applications*.

***Type TCO-1 . . .*** Temperature control oven . . . for performance ± .0001% between −55°C and +70°C . . . specify BH6 crystal units with TCO-1 temperature control ovens. (For dual units specify TCO-2). Precision performance based on Bliley's *complete knowledge of temperature control ovens*.

"First . . . For 20 Years"

Bliley CRYSTALS

BLILEY ELECTRIC COMPANY
UNION STATION BLDG., ERIE, PA.

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 56A)*

## Microwave Matching Transformers

**Polytechnic Research and Development Co., Inc.,** 202 Tillary St., Brooklyn 1, N. Y. announce the development of a series of EH tuners providing coverage of the 12.4 to 40.0 kmcs band.

These matching transformers consist of hybrid-tee junctions in which movable choke-type shorts are placed in the shunt and series arms. By proper adjustment it is possible to reduce to a value less than 1.02 VSWR as high as 20.1 and of arbitrary phase.

## Portable Television Field-Strength Meter

A lightweight, portable television field strength meter, Model A-460, has just been introduced by **Approved Electronic Instrument Corp.,** 142 Liberty St., New York 6, N. Y.

Designed with self-contained power supply, 115 volts, 60 cps (65 watts), housed in a heavy gauge steel cabinet, the unit is said to reduce the work of installing a television receiver to one man. The field-strength meter is calibrated from 50 to 30,000 microvolts. An all-channel selector on the panel is designed for fine tuning control.

*(Continued on page 58A)*


SPECIFY

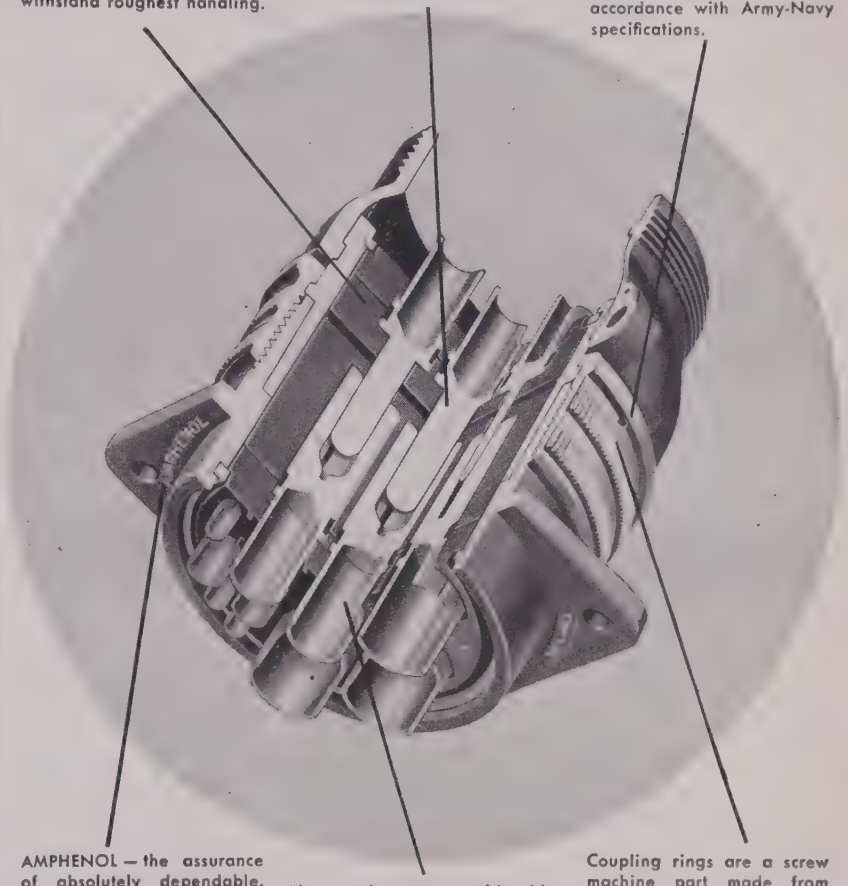
AMPHENOL

"AN" CONNECTORS

On sizes 20 and up, Amphenol provides 70% thicker inserts . . . stronger to withstand roughest handling.

Contacts are selected high conductivity bronze alloys, silver plated and with pockets pretinned for soldering.

Both coupling rings and assembly screws are cross-drilled for safety wiring in accordance with Army-Navy specifications.



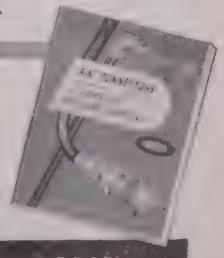
AMPHENOL — the assurance of absolutely dependable, weatherproof, vibration-proof service.

Non-rotating contacts with solder cups are uniformly aligned . . . saves 40% in assembling time, lowers cost.

Coupling rings are a screw machine part made from solid aluminum bar stock providing 80% greater tensile strength.

FOR POWER, SIGNAL and CONTROL CIRCUITS in AIRCRAFT and ELECTRONIC EQUIPMENT

Amphenol engineers and technicians are available without obligation to assist in specifying the right type of "AN" connector for application in instrument, power and control problems. Amphenol "AN" Connectors are available in five major shell designs, each accommodating over 200 styles of contact inserts.



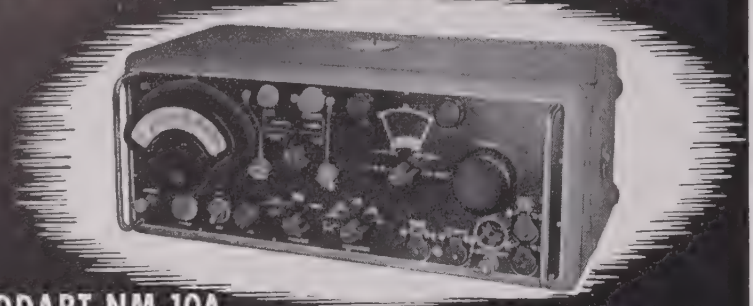
COMPLETE LISTINGS OF "AN" CONNECTORS

*Write for your copy of Amphenol's comprehensive and illustrated catalog on "AN" and "97" Connectors. Please send request on company letterhead.*

AMERICAN PHENOLIC CORPORATION

1830 SO. 54TH AVENUE • CHICAGO 50, ILLINOIS

# V.L.F.!
## Very Low Frequencies covered by the . . .



## STODDART NM-10A
## RADIO INTERFERENCE AND FIELD INTENSITY METER

- MEASURES radiated and conducted signals, including pulse or random interference.
- RANGE—14 kc to 250 kc.
- SENSITIVITY — Field strength using rod antennas one microvolt-per-meter to 2 volts-per-meter. Field strength using shielded loop antennas 10 microvolts-per-meter to 100 volts-per-meter. As a two-terminal voltmeter, either balanced or unbalanced, one microvolt to one volt.
- READS directly in microvolts and db.
- A.C. POWER SUPPLY REQUIREMENTS 105 to 125 volts or 210 to 250 volts A.C. Single phase source may be ANY FREQUENCY BETWEEN 50 CPS AND 1600 CPS. No shock hazard.
- GRAPHIC RECORDER included with versatile complement of accessories.

Write for complete technical data

**STODDART AIRCRAFT RADIO CO.**

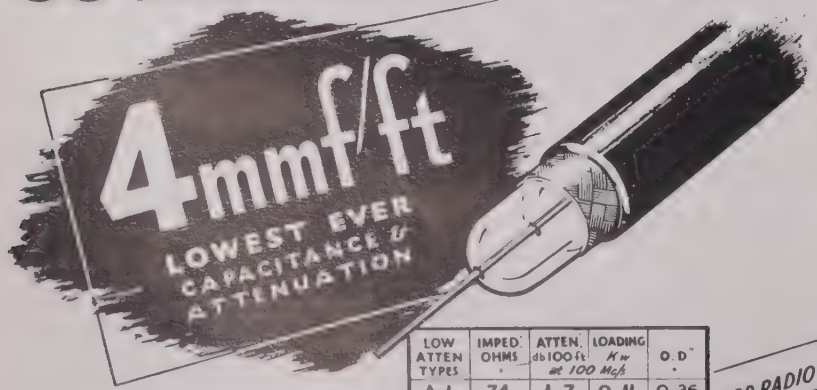
Main office and plant: 6644 Santa Monica Blvd. Hollywood 38, Calif. Phone: Hillside 9294

8-247 General Motors Bldg. Detroit 2, Michigan Phone: Trinity 1-9260

1346 Connecticut Ave. duPont Circle Bldg. Washington 6, D. C. Phone: Hudson 7313



# CO-AX AIR-SPACED ARTICULATED R.F. CABLES




| | LOW ATTEN TYPES | IMPED. OHMS | ATTEN. db/100 ft at 100 Mc/s | LOADING Kw | O.D" |
|---|---|---|---|---|---|
| HIGH POWER FLEXIBLE | A.1 | 74 | 1.7 | 0.11 | 0.36 |
| | A.2 | 74 | 1.3 | 0.24 | 0.44 |
| | A.34 | 73 | 0.6 | 1.5 | 0.85 |

FOR RADIO FREQUENCIES

| | LOW CAPAC. TYPES | CAPAC. mmf/ft | IMPED. OHMS | ATTEN. db/100ft 100 Mc/s | O.D" |
|---|---|---|---|---|---|
| PHOTOCELL CABLE | C.1 | 7.3 | 150 | 2.5 | 0.36 |
| | P.C.1 | 10.2 | 132 | 3.1 | 0.36 |
| | C.11 | 6.3 | 173 | 3.2 | 0.36 |
| | C.2 | 6.3 | 171 | 2.15 | 0.44 |
| | C.22 | 5.5 | 184 | 2.8 | 0.44 |
| | C.3 | 5.4 | 197 | 1.9 | 0.64 |
| VERY LOW CAPACITANCE CABLES | C.33 | 4.8 | 220 | 2.4 | 0.64 |
| | C.44 | 4.1 | 252 | 2.1 | 1.03 |

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CABLES: TRANSRAD · LONDON

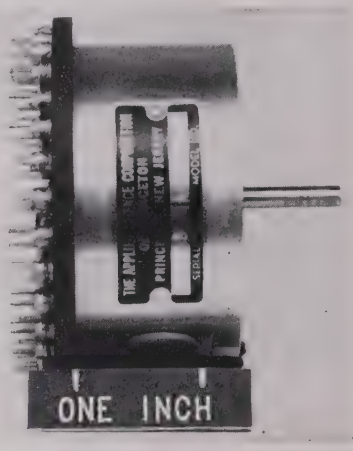

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 57A)*

## High-Speed Mechanical Sampling Device

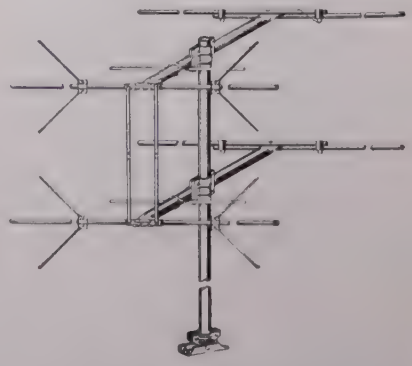
The development of a new high-speed mechanical sampling device with sampling rates up to and exceeding 5,000 cycles per minute, successfully achieved with good life, is announced by **The Applied Science Corp. of Princeton,** PO Box 44, Princeton, N. J.




The switch is so designed that it may be driven by an external shaft thus permitting direct synchronization of electrical circuits with mechanical motion. The device may also be furnished in one unit with driving motor of any design or speed within the above limits. It is completely encased as a protection against foreign material, and it is said to be operable at wide temperature ranges and under high forces of acceleration. Sixty make-before-break contacts are sampled each cycle.

## New TV Antenna

A new version of the Taco Lazy H antenna is announced by **Technical Appliance Corp.,** Sherburne, N. Y.



The Taco Type 912 incorporates all the latest developments in TV design. Spacing has been changed to render better performance throughout the 12 channels. High-frequency whiskers are added to the

*(Continued on page 59A)*

# News—New Products

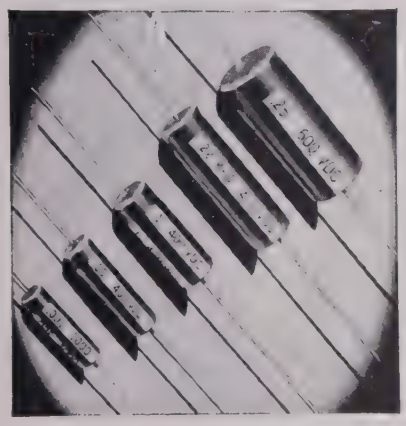
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 58A)*

dipoles to give a single lobe of greater gain in the high frequencies. An additional reflector is so spaced to serve these higher channels. The Type 912 is of all-aluminum construction except at points of insulation.

## Paper Tubular Capacitor

A tubular capacitor, Type '87, said to approach the performance of a plastic-molded type without the additional cost, is announced by **Aerovox Corp.**, New Bedford, Mass.



Molded in its own paper tube, the Type '87 has the appearance of the usual paper tube, with the exception of the Duranite sealed ends. An over-all wax dip further adds to the high humidity resistant characteristic. These new tubulars can be used without drips at 212° F. The absence of impregnating oils and waxes eliminates dripping or cracking of the wax coating which interaction might cause. It is further claimed that its dielectric strength at elevated temperatures is such that it can be operated at the rated voltage of 212°F. without danger.

## Two New Tube Types

The initial production of two new tube types, the 1X2 and the 6BQ6GT, is announced by **Raytheon Mfg. Co., Radio Receiving Tube Div.,** 55 Chapel St., Newton 58, Mass.

The 1X2 is a filament-type rectifier of miniature construction designed for use in television receivers as a high-voltage rectifier. It can be used in RF, flyback, and power line frequency types of rectifier circuits.

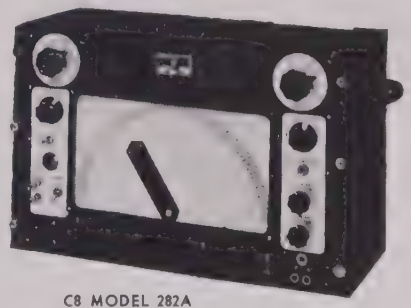
The 6BQ6GT is a beam pentode for use as a horizontal deflection amplifier in television receivers. Employing a T-9 bulb and a standard octal base, space savings can be effected. The plate connection is made through a top cap to allow for better isolation of the high plate voltage.

*(Continued on page 60A)*


**NEW! THE CB AUTOMATIC AUDIO SWEEP GENERATOR**

25 CYCLES TO 32,000 CYCLES IN ONE CONTINUOUS RANGE—WAVE FORM DISTORTION .005 (½ %) OR LESS — MANUAL OR AUTOMATIC OPERATION

Automatic Range adjustable from a minimum spread of 500 cycles to a maximum spread of 10,000 cycles. Sweep calibration is LINEAR and is adjustable from 2 to 10 sweeps per second.



CB MODEL 282A

The new CB Model 282A is built to highest precision instrument standards and has a wide application range. For complete construction details and performance data, write for Bulletin 27A.

**The CLOUGH BRENGLE CO.**

6012 Broadway Chicago 40, Ill.

**KENYON** *Fits Your Production To A "T"*

**KENYON** "T's"—high quality, uniform transformers, are your best bet for development, production and experimental work. For over 20 years, the KENYON "K" has been a sign of skillful engineering, progressive design and sound construction.

Now—reduce inventory problems, improve deliveries, maintain your quality—specify KENYON "T's," the finest transformer line for all high quality equipment applications.

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**KENYON** new modified edition tells the complete story about specific ratings on all transformers. Our standard line saves you time and expense.

Send for your copy of our latest catalog edition *now!*

**KENYON TRANSFORMER CO., Inc.**

840 BARRY STREET · NEW YORK 59, N. Y.

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 59A)*

## Portable Beta and Gamma Detector

Designed and built exclusively for prospecting use by **Kelley-Koett Mfg. Co.** West Fourth St., Covington, Ky., the "Prospector," Model K-802, detects and measures beta and gamma rays emitted by uranium and other radioactive substances.

Two standard flashlight batteries power the unit through a vibrator power supply which furnishes the high voltage for the Geiger tube. The tube itself is a plug-in type, easily replaceable in the field. An off-on switch control is employed.

Small ($6\frac{1}{2}$ inches $\times 3\frac{3}{4}$ inches $\times 2\frac{1}{4}$ inches) and light (2 lbs.), the "Prospector" can be carried in the hand by the plastic strap, hooked on the belt, or in the pocket.

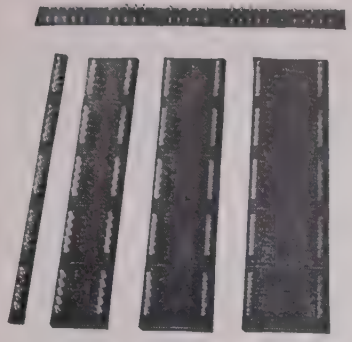
For further details on this and other Kelley-Koett electronic instruments, write to the company for bulletin E-5.

## High-Current Dual Rectifier Elements

According to claims, the largest known dual selenium rectifier elements have been developed by the **International Rectifier Corp.**, 6809 South Victoria Ave., Los Angeles 43, Calif.

*(Continued on page 61A)*

COVERING THE ENTIRE RANGE OF COMPONENTS...



CTC ALL-SET Boards Speed Up Work On Assembly Lines And In Laboratories

CTC *ALL-SET* Boards are designed to save time and cut costs over a wide range of standard assembly operations.

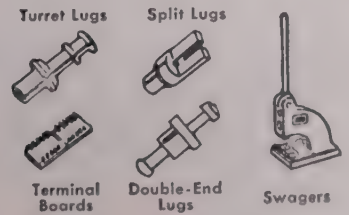
Boards with Type 1724 Turret Lugs come in four widths: ½", 2", 2½", 3"; and in thicknesses of 3/32", ⅛", 3/16". A Board with Type 1558 Turret Lugs, for miniature components, is 1 1/16" wide, with thicknesses of 1/16" and 3/32" only (Type X1401E). This new miniature Board completes the CTC ALL-SET group.

Boards are all of laminated phenolic, in five-section units scribed for easy separation. Each section is drilled for 14 lugs, with 10 mounted, except X1401A (½" wide), which is drilled for 7 lugs per section, with 5 mounted. All lugs are solidly and precisely swaged, and each whole board is ready for assembly.

**Custom-Built Boards**

are an important specialty at CTC. Avail yourself of our long experience in handling the widest range of materials and jobs — many of them requiring special tools — and in all types of work to commercial or government specifications.

CTC *ALL-SET* Terminal Boards, Custom-Built Boards and many other CTC *Guaranteed Components* are described and illustrated in our big new catalog #300. Send for your copy today.




*Custom or Standard*
*The Guaranteed Components*

CAMBRIDGE THERMIONIC CORP.
456 Concord Ave., Cambridge 38, Mass.

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 60A)*

Each dual element consists of two of the company's largest size (6¼ inches by 7¼ inches) plates strapped in parallel and rated in a three-phase bridge circuit at 34 amperes for continuous duty self-cooling, 85 amperes for continuous duty fan-cooling, and 340 amperes for highly intermittent duty. These dual elements are assembled in a three phase bridge heavy-duty 10-kw rectifier stack rated at 1,500 amperes for such applications as magnetic inspection, etc. The stacks are designed on the basis of 16 kw per cubic foot and are provided with an interlocked assembly to prevent lug misalignment and plate rotation.

Operating efficiencies of 85 per cent can be obtained, and when aluminum plates are used, the weight per dual element minus the hardware is 9 ounces. Each 1,500 ampere stack is 7¼ inches wide by 12 inches long by 14½ inches high.

## Shielded Enclosure for RF Interference Evaluation

A screen room has been designed to help determine rf interference evaluation and suppression at levels as low as 1 microvolt in areas of undesired interference as high as 100,000 microvolts. Construction and engineering is by: **Ace Engineering & Machine Co., Inc.**, 3644 N. Lawrence St., Philadelphia 40, Pa.

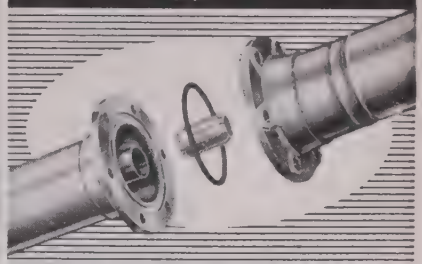
These rooms are constructed with cell-type panels eliminating the necessity of insulating the inner and outer shields from each other. Soldering between sections is not necessary. With panel construction, room size and location do not have to remain fixed.

Exclusive of the power line filters attenuation characteristics, the rooms provide not less than 100-db attenuation from 0.15 to 1,000 Mc.

Standard rooms are 7 feet high, 8 feet wide, and any length desired.

*(Continued on page 62A)*

JOHNSON *Offers-*



LONG-FLANGE CO-AX LINE...

GREATER MECHANICAL STRENGTH
No Brazing—No Cracking—No Distortion!
Solder Joint Stronger Than Tubing Itself!

This is the type of copper tubing joint which has proved most successful in other applications for many years!

There is less distortion, better all-around contact—a joint that is stronger than the tubing itself!

JOHNSON hard temper, 70 ohm, and 51.5 ohm, flange type line is supplied in 20 foot lengths. Special high conductivity copper is used in both outer and inner conductors and rigid tolerances are maintained to insure precision mechanical assembly, low loss and low standing wave ratio.

The 70 ohm line is intended primarily for AM and has grade L-4 or better steatite beads. The 51.5 ohm line was designed primarily for high frequencies, has grade L-5 or better steatite and meets RMA standards for FM line. Both are fitted with flange couplings at the factory, which greatly simplifies field installation.

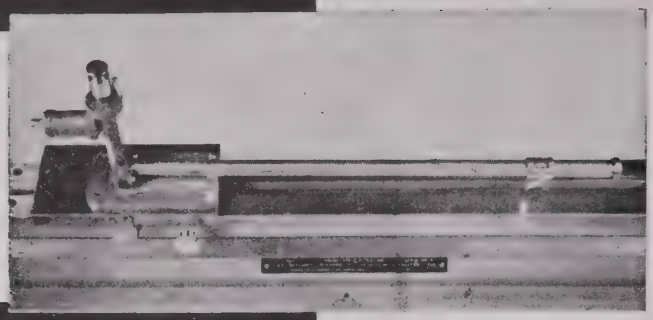
In addition, JOHNSON manufactures a complete line of elbows, fittings, gas equipment and hardware for the above as well as semi-flexible, soft temper line in continuous lengths up to 1200 feet in 5/16", 3/8" and 7/8". No expansion joints nor elbows are needed for the latter because of its flexibility.

The 5/16" line is especially recommended for phase sampling and other low power applications.

Whatever your co-ax requirements may be, JOHNSON — the oldest manufacturer of concentric line in the field — can meet them to your utmost satisfaction.

JOHNSON
E. F. JOHNSON CO., WASECA, MINN.

# PRECISION



FTL-30A SLOTTED LINE

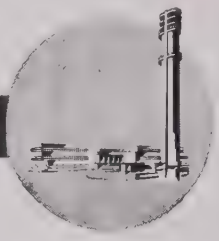
Designed for making impedance, standing wave ratio, and wavelength measurements in the range of 60 to 1000 megacycles per second.

Careful design and precision manufacture enable highly accurate measurements to be made with the line.

High sensitivity and selectivity due to efficient probe tuning.

End connectors adapted to use of Type N or similar fittings for solid dielectric cables as well as for 7/8, 1 5/8 and 3 1/8 inch air lines.

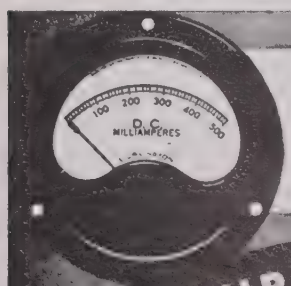
Write for complete FTL-30A Brochure



Federal Telecommunication Laboratories, Inc.

500 WASHINGTON AVE. An IT&T Associate NUTLEY 10, N. J.

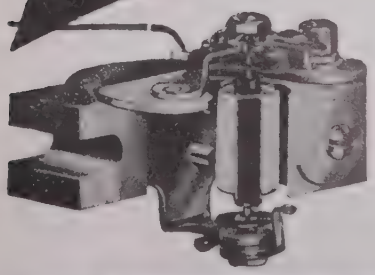





ONE OF A SERIES

PLATED PARTS

WHY BURLINGTON PANEL INSTRUMENTS PROVIDE UTMOST RELIABILITY . . .



By maintaining its own plating facilities, Burlington assures proper control and protection of components against rust and corrosion. All ranges AC and DC available in rectangular or round case styles and are guaranteed for one year against defects in workmanship or materials. Refer inquiries to Dept. I-119.

Burlington INSTRUMENT COMPANY
BURLINGTON, IOWA


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 61A)*

## Kit Form Signal Generator

**Electronic Measurements Corp.**, 423 Broome St., New York 13, N. Y., has announced the marketing of their Model 500K RF Signal Generator in kit form.

The generator covers a range from 150 kc to over 30 Mc on fundamentals and over 100 Mc on harmonics. The manufacturer also announces that 400-cps internal modulation is also available, and provision is made for external modulation. One of the outstanding features of the generator is the fact that all coils not in use are automatically shorted out. It employs an electrostatically shielded transformer for 115-volt, 60-cycle operation.

## Calibrated Pre-Amplifier

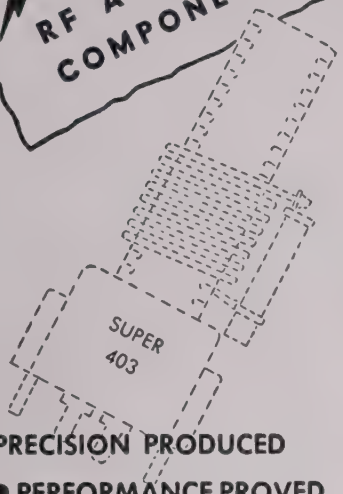
Designed by the **Sound Apparatus Co.**, Stirling, N. J., to extend the sensitivity of their line of graphic recorders to 30 microvolts, the Model PR calibrated preamplifier is an all-purpose self-contained laboratory instrument, equally suitable for portable applications.

A flat response from 40 to 40,000 cps, a dynamic range in excess of 60 db, and a calibrated gain control in 5 db steps from 0 to 50 db, gives a calibrated amplification into a low output impedance. The Model PR amplifier is available with a selection of input impedances for use with a multiplicity of low-output devices.

*(Continued on page 63A)*

# NOTE THIS NAME

SUPER RF AUDIO TV COMPONENTS




● PRECISION PRODUCED

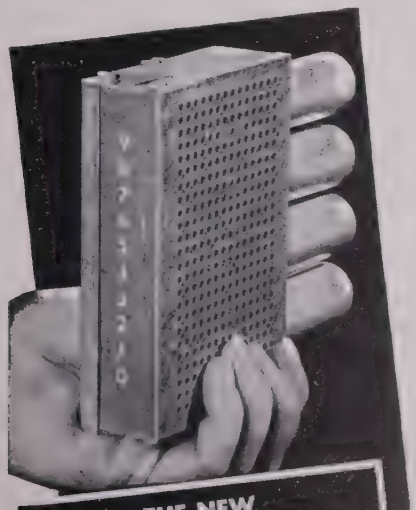
● PERFORMANCE PROVED

**SUPER ELECTRIC PRODUCTS CORP.**

*Pacing Electronic Progress With Ingenuity*

**1057 Summit Ave., Jersey City 7, N. J.**





THE NEW **BERKELEY** MODEL 700 DECIMAL COUNTING UNIT

This unique packaged component is *easily built into* your apparatus. It has *true decimal reading*, and simple binary circuit with reliable *automatic interpolation*. Miniature size. Moderate price. Immediate shipment.

*Send for Bulletin DCU-116*

**Berkeley Scientific Company**

SIXTH AND HEVIN AVE • RICHMOND, CALIFORNIA


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 62A)*

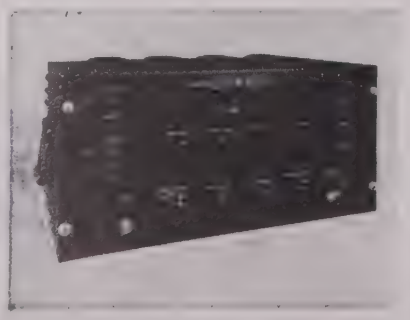
## Miniature Pentagrid Converter Tube

A new miniature pentagrid converter tube, designed especially for use in compact, light-weight portable radio receivers, where high operating efficiency at low plate voltages are desired, has been announced by the **Radio Div. of Sylvania Electric Products Inc.,** 500 Fifth Ave., New York 18, N. Y

The new tube, type 1L6, is supplied with a 1.4-volt dc filament cathode rated at 50 ma. Operated from a 90-volt B supply, its plate current is only 0.50 ma.

## Sweep Calibrator

Designed to provide markers for accurate time calibration of synchroscopic sweeps, a new sweep calibrator, Model GL-22A, is announced by **Browning Laboratories, Inc.,** 750 Main St., Winchester, Mass.



Markers at intervals of 0.1, 1.0, 10.0 and 100.0 microseconds are provided and are suitable for deflection-indicating or beam-blanking presentation. A self-contained trigger generator with positive or negative output can be used to drive the calibrator and associated equipment, or it may be triggered externally up to approximately 100 kc. Positive or negative gates

*(Continued on page 64A)*

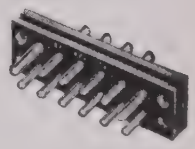

MORE

# CANNON PLUGS

## FOR THE RADIO TECHNICIAN

**TYPE DP**

Rack & Panel type connectors with a variety of standard and coaxial contacts.



**LABORATORY AND SWITCHBOARD**

Connectors for experimental switchboards and testing equipment; 1 to 4 contacts; 75-amp.

**TYPE AP**

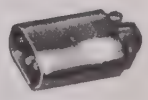
Seven different insert arrangements same as Type "P" 30 and 15-amp. rating, but with heavier shell, gasketed for weather resistance; coupling nut extraction means; cable clamp plug entries.

**TYPE XK**

Same inserts as Type "X"—1, 3 and 4 contacts; for No. 14 and 16 wire; coupling nut extraction means.

**TYPE O**

Latchlock sound-microphone series with oval shell; 3 contacts for No. 10 wire, 30 amperes.



**AND 8 OTHER MAJOR TYPE SERIES**—More than 400 radio parts distributors in the USA handle Cannon Plugs . . . twenty-six representatives located in principal cities are at your service. Or write direct to factory for new C-48 Condensed General Catalog, 32 pages of data and prices.

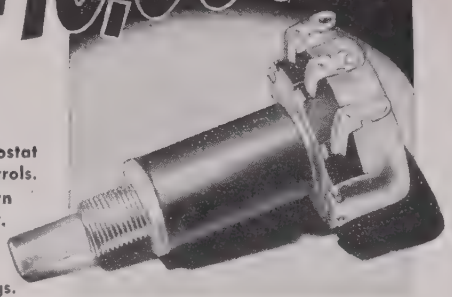
Cannon Electric also manufactures signal equipment for hospitals, industrial plants, schools, institutions and many other electrical specialties such as conduit fittings, D. C. Solenoids, fire alarm relays, cable terminals, indicator and pilot lights, etc., etc.

Address Cannon Electric Development Co., Division of Cannon Manufacturing Corporation, 3209 Humboldt St., Los Angeles 31, Calif. Canadian offices and plant: Toronto, Ontario. World export: Frazar & Hansen, San Francisco.

SINCE 1915

**CANNON ELECTRIC**

# SAFE at 10,000 V.!



★ Factory-fitted to most Clarostat carbon and wire-wound controls.
★ Control-to-ground breakdown rating better than 10,000 v.
★ New design eliminates troublesome backlash. Permits more critical settings.

## IMPROVED HIGH-VOLTAGE CONTROLS

Improved design high-voltage controls for TV sets, oscillographs and other high-voltage electronic assemblies. Safe operation up to 10,000 v.

Straight-through plastic shaft simplifies and improves operation. No back-lash to throw off critical adjustments. Cheaper. Better. Simpler.

**Ask for Bulletin No. 120.**
**Let us quote on your needs.**

1949 IS TV YEAR

CLAROSTAT

*Controls and Resistors*

CLAROSTAT MFG. CO., INC. • DOVER, NEW HAMPSHIRE • *In Canada:* CANADIAN MARCONI CO., LTD. *Montreal, P. Q., and branches*

# 200 MC BAND WIDTH AMPLIFIERS

**Model 202P Wide-Band Chain Amplifier with Regulated Power Supply.**

**Band Width: 100 KC to 200 MC. Gain: 20 db.**
**Impedance: 200 ohms. Rise Time: Less than .003 usec.**
**With the Model 202P:** very fast pulses, transients and other high frequency voltages can now be amplified.
**With the Model 202P:** vacuum tube voltmeters and oscilloscopes are ten times more sensitive.
**With the Model 202P:** the output voltage of signal, sweep and pulse generators is ten times greater.

*Other Wide-Band Chain Amplifiers available:*
**Model 200A — 10 db Gain. Model 204 — 40 db Gain.**

Makers of chain amplifiers, temperature controls, variable electronic filters and power supplies.
*Write for Bulletin 202P-1-R*

**SKL SPENCER-KENNEDY LABORATORIES, INC.**
**186 MASSACHUSETTS AVE., CAMBRIDGE 39, MASS.**


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 63A)*

of variable amplitude are available for obscuring retrace or timing purposes.

The design is flexible and permits operation in conjunction with any type of oscilloscope having synchroscope or triggered sweep facilities.

## Rotary Actuators

To meet the increasing requirements of military aircraft for powerful, light-weight rotary actuators, **Lear, Inc., Electro-mechanical Div.,** 110 Ionia Ave., N.W., Grand Rapids 2, Mich., announces the new Model Series 186, 188 and 189.

Basic features of these actuators are split-field, reversible, explosion-proof dc motor, electromagnetic brake, planetary gear assembly and circuit switch assembly within a small envelope, and with weight reductions up to 75 per cent over former models. Standard gear assemblies are designed to withstand a maximum load of 45 ounce-inches, special designs up to 200 ounce-inches.

For further details and catalog, contact Lear, Inc.

## Du Mont Announces Plan to Repurchase VHF Transmitters

The television Transmitter Div., **Allen B. Du Mont Laboratories, Inc.,** 42 Harding Ave., Clifton, N. J. have announced plans to repurchase Du Mont vhf transmitters from TV broadcasters and CP holders who, for the best interests of the public and television broadcasting industry, may be required to change operations from the vhf band to the uhf band.

The plan, outlined in individual letters to purchasers of complete Du Mont video and audio transmitters, provides for the repurchase of Du Mont vhf transmitters at an amount equal to the total depreciated value of the transmitter at the time it is repurchased by Du Mont. The repurchase value, which is applied as a credit against the purchase of a Du Mont uhf transmitter, is computed on a straight-line semi-annual basis which adheres as completely as possible to established procedures in determining depreciation.

*(Continued on page 65A)*

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 64A)*

## Recent Catalogs

• • • An 8-page brochure describing the operation and uses of its new high-speed rectangular co-ordinate recorder, type 373, by **Airborne Instruments Laboratory Inc.**, Mineola, N. Y.

• • • The third edition of the Stancor Television Components Replacement Guide, Bulletin DD338B, 4 pages of reference data on replacements for use in 108 television receiver models by **Standard Transformer Corp.**, 3580 Elston Ave., Chicago 18, Ill. Available from Stancor parts distributors or direct from company.

• • • A 196-page catalog covering "everything in radio and electronics" with special emphasis on equipment for industrial maintenance, research, and production requirements by **Allied Radio Corp.**, 833 W. Jackson Blvd., Chicago 7, Ill.

• • • A 6-page bulletin describing the 2" high precision linear and nonlinear potentiometers together with general information on nonlinear potentiometers was issued by **Technology Instrument Corp.**, 1058 Main St., Waltham 54, Mass.

• • • Catalog D-20A giving contact ratings, coil specifications, sizes, and general information on industrial and general purpose relays carried in stock by **Ward Leonard Electric Co.**, Electronic Distributor Div., 53 W. Jackson Blvd., Chicago 4, Ill.

• • • A 12-page booklet dealing with new Du Mont types 304 and 304-H cathode-ray oscillographs, successors to the type 208-B, was released by **Allan B. Du Mont Laboratories,** Instrument Div., 1000 Main Ave., Clifton, N. J.

• • • A new booklet, DB-19-025, of Westinghouse standard and high-voltage selenium rectifiers for power supplies and electronic circuits; efficiency curves for both the standard (type **M**) and high-voltage (type **H** cells) are included. For a copy, write **Westinghouse Electric Corp.**, PO Box 868, Pittsburgh 30, Pa.

• • • An illustrated booklet presenting the history and describing the plants, departments, and products of the **Electrical Reactance Corp.**, Franklinville, N. Y

• • • A revised edition of a comprehensive technical manual containing basic application data for 637 radio receiving tube types and cathode-ray tubes used by circuit designers, radio and television set repairmen and industrial electronic engineers has been announced by the **Radio Division, Sylvania Electric Products Inc.**, Emporium, Pa.

*(Continued on page 68A)*


NEW... Improved Wiring Eliminates Leakage

TYPE 12AT & TYPE 12ATK (KIT)

TRANSMISSION MEASURING SET

Range: 111 db. in 0.2 steps.
Frequency resp.: 0.1 db. from 0 to 20 kc.
Accuracy: 0.1 db.
Impedance, load section: 4, 8, 16, 50, 150, 200, 500, & 600 ohms.
Impedance, transm. set.: 50, 150, 200, 500 & 600 ohms.
Reference level: 1mw. into 600 ohms.
Circuit: "T", unbalanced.
Attenuators: 10x10, 10x1 & 5x0.2 db.
Load carr. cap.: Transm. sect. 1 w. Load section 10 w.

A precision Gain Set with specially developed wiring that permits no troublesome leakage and provides improved frequency characteristics. Available completely assembled, or in kit form—which permits the sale of a high accuracy instrument at a low price.

WRITE FOR DESCRIPTIVE BULLETIN

TECH LABORATORIES, INC.

Manufacturers of Precision Electrical Resistance Instruments

PALISADES PARK, NEW JERSEY

MEASUREMENTS CORPORATION MODEL 80

STANDARD SIGNAL GENERATOR

2 to 400 MEGACYCLES

MANUFACTURERS OF
Standard Signal Generators
Pulse Generators
FM Signal Generators
Square Wave Generators
Vacuum Tube Voltmeters
UHF Radio Noise & Field Strength Meters
Capacity Bridges
Megohm Meters
Phase Sequence Indicators
Television and FM Test Equipment

MODULATION: Amplitude modulation is continuously variable from 0 to 30%, indicated by a meter on the panel. An internal 400 or 1000 cycle audio oscillator is provided. Modulation may also be applied from an external source. Pulse modulation may be applied to the oscillator from an external source through a special connector. Pulses of 1 microsecond can be obtained at higher carrier frequencies.

FREQUENCY ACCURACY ±.5%

OUTPUT VOLTAGE 0.1 to 100,000 microvolts

OUTPUT IMPEDANCE 50 ohms

MEASUREMENTS CORPORATION

BOONTON NEW JERSEY

# R. F. COMPONENTS–MICROWAVE–TEST EQUIPMENT

## 10 CENTIMETER

**WAVEGUIDE TO 7/8" RIGID COAX "DOORKNOB" ADAPTER. CHOKE FLANGE. SILVER PLATED BROAD BAND** .....$49.50 ea.
**WAVEGUIDE DIRECTIONAL COUPLER,** 27 db. Navy type CABV-47AAN, with 4 in. slotted section .....$42.50
**SQ. FLANGE** to rd choke adapter, 18 in. long OA 1½ in. x 3 in. guide, type "N" output and sampling probe .....$32.00
**Crystal Mixer** with tunable output TR pick up loop, Type "N" connectors. Type 62ABH $14.50
**Slotted line probe.** Probe depth adjustable, Sperry connector, type CPR-14AAO .$9.50
**Coaxial slotted section,** ⅝" rigid coax with carriage and probe .....$25.00
**Waveguide Transition** from 1½" x 3" to 2" x 1" .....$45.00
**Right Angle Bend** 6" radius E or H plain $27.50
**Right Angle Bend** 3" radius E or H plain—Circular flanges .....$17.50
**AN/APR5A** 10 cm antenna equipment consisting of two 10 CM waveguide sections, each polarized. 45 degrees .....$75.00 per set
**APN-7 TR Cavity** for 721A, with tuning slugs .....$5.50 ea.
**PICKUP LOOP,** Type "N" Output .... $2.75
**TR BOX** Pick-up Loop .....$1.25
**POWER SPLITTER:** 726 Klystron input dual "N" output .....$5.00
**MAGNETRON TO WAVEGUIDE** coupler with 721-A duplexer cavity, gold plated .$27.50
**10 CM WAVEGUIDE SWITCHING UNIT,** switches 1 input to any of 3 outputs. Standard 1½" x 3" guide with square flanges. Complete with 115 vac or dc arranged switching motor. Mfg. Raytheon. CRP 24AAS. New and complete .....$150.00
**10 CM END-FIRE ARRAY POLYRODS $1.75 ea.**
**"S" BAND** Mixer Assembly, with crystal mount, pick-up loop, tunable output .....$3.00
**721-A TR CAVITY WITH TUBE.** Complete with tuning plungers .....$12.50
**10 CM. McNALLY CAVITY** Type SG ...$3.50
Type SF .....$4.50
**WAVEGUIDE SECTION,** MC 445A, rt. angle bend, 5½" ft. OA. 8" slotted section ..$21.00
**10 CM OSC. PICKUP LOOP,** with male Homedell output .....$2.00
**10 CM DIPOLE WITH REFLECTOR** in lucite ball, with type "N" or Sperry fitting ..$4.50
**10 CM FEEDBACK DIPOLE ANTENNA,** in lucite ball, for use with parabola 7/8" Rigid Coax Input .....$8.00
**PHASE SHIFTER.** 10 CM WAVEGUIDE, WE TYPE ES-683816. E PLANE TO H PLANE, MATCHING SLUGS .....$95.00
**721A TR cavities.** Heavy silver plated $2.00 ea.
**10 cm. horn and rotating** joint assembly, gold plated .....$65.00 ea.

### 7/8" RIGID COAX—3/8" I.C.

**7/8" rigid coaxial tuning stubs** with vernier stub adjustment. Gold Plated .....$17.50
**7/8 RIGID COAX ROTARY JOINT.** Pressurized, Sperry #810613. Gold Plated ..... $27.50
Dipole assembly. Part of SCR-584 ....$25.00 ea.
Rotary joint. Part of SCR-584 .....$35.00 ea.
**RIGHT ANGLE BEND,** with flexible coax output pickup loop .....$8.00
**SHORT RIGHT ANGLE BEND,** with pressurizing nipple .....$3.00
**RIGID COAX** to flex coax connector .....$3.50
**STUB-SUPPORTED RIGID COAX,** gold plated 5' lengths. Per length .....$5.00
**RT. ANGLES** for above .....$2.50
**RT. ANGLE BEND 15" L. OA** .....$3.50
**FLEXIBLE SECTION,** 15" L. Male to female $4.25
**MAGNETRON COUPLINGS** to 7/8" rigid coax. with TR pickup loop, gold plated ....$7.50
**FLEX COAX SECT.** Approx. 30 ft. .....$16.50

### 7/8" RIGID 1/4" IC

**CG 54/U**—4 foot flexible section 1/4" IC pressurized .....$15.00
7/8 RIGID COAX. Bead Supported .....$1.20
**SHORT RIGHT ANGLE BEND** .....$2.50
Rotating joint, with deck mounting .. $15.00
**RIGID COAX** slotted section CU-60/AP $5.00

### WAVEGUIDE

1/2" x 1/4" ID .....$1.00 per foot
1" x 1/2" OD ..... 1.50 per foot
5/8" x 1¼" OD ..... 1.65 per foot
5/8" x 1¼" OD Aluminum ..... .75 per foot
1½" x 3" OD ..... 3.00 per foot
2½" x 3" OD ..... 3.50 per foot
1" x ½" OD Flexible .....4.00 per foot
7/8" rigid coax ¼" IC ..... 1.20 per foot
(Available in 10FT to 15ft. lengths or smaller.)
**UG 65/U** 10CM flanges .....$6.75 each
**UG 53/U** Cover ..... 4.00 each
**UG 54/U** Choke ..... 4.50 each

## 3 CENTIMETER

**(STD. 1" x ½" GUIDE UNLESS OTHERWISE SPECIFIED)**
**723 A/B Klystron mixer section** with crystal mount, choke flange and Iris flange output .....$22.50
**TR-ATR Section** for above with 724 ATR Cavity $8.50
**90 degree twist,** 6 inches long .....$8.00
**723 AB Mixer**—Beacon Dual Oscillator Mount with Crystal holder ..... $12.00
**2 Way Wave Guide directional coupler,** type N fitting 1⅛" x ⅝" guide 26DB .....$18.50
**CG 98B/APG 13,** 12" flexible section 1¼" x ⅝" OD .....$10.00
**TR-ATR Section,** APS 15, for 1B24, with 724 ATR Cavity with 1B24 and 724 tubes. Complete $21.00
**Crystal mount** in waveguide .....$17.50
**Stabilizer Cavity** with bellows .....$21.50
**3 cm. 180° bend with pressurizing nipple** $6.00 ea.
**3 cm. 90 bend,** 14" long 90° twist with pressurizing nipple .....$6.00 ea.
**3 cm.** "S" curve 18" long.....$5.50 ea.
**3 cm.** "S" curve 6" long .....$3.50 ea.
**3 cm. right angle bends.** "E" plane 18" long cover to cover .....$6.50 ea.
**3 cm. Cutler feed dipole.** 11" from parabola mount to feed back .....$8.50 ea.
**TWIST** 45 deg.. 6" long .....$8.00
**APS-31 mixer section** for mounting two 2K25's. Beacon reference cavity 1B24 TR tube. New and complete with attenuating slugs $42.50 ea.
**DUPLEXER SECTION** for 1B24 .....$10.00
**CIRCULAR CHOKE FLANGES,** solid brass .55
**SQ. FLANGES, FLAT BRASS** .....ea. .55
**FLEX. WAVEGUIDE** .....$4.00/Ft.
**TRANSITION** 1 x ½ to 1¼ x ⅝, 14 in. ..$8.00
**"X" BAND PREAMPLIFIER,** consisting of 2-723 A/B local oscillator-beacon feeding waveguide and **TR/ATR** Duplexer sect. incl. 30MC Pre Amp .....$67.50
**Random Lengths waveqd,** 6" to 18" Lg. $1.10/Ft.
**WAVEGUIDE RUN.** 1¼" x ½" guide, consisting of 4 ft. section with Rt. angle bend on one end 2" 45 deg. bend other end ..$8.00
**WAVEGUIDE RUN, 1¼" x ½" guide,** consisting of 4 ft. long .....$10.00
12" **SECTION** 45 deg twist 90 deg bend $6.00
**11" STRAIGHT WAVEGUIDE** section choke to cover. Special heavy Construction, silver plated .....$4.50
**15 DEG BEND** 10" choke to cover .....$4.50
**5 FT. SECTIONS choke to cover,** Silver Plated $10.00
**18" FLEXIBLE SECTION** .....$17.50
**"X" BAND WAVEGUIDE** 1¼" x ⅝" OD 1/16" wall Alluminum .....Per Foot $ .75
**WAVEGUIDE** 1" x ½" I.D. .....Per Foot $1.50
**TR CAVITY** For 724 A TR Tube .. ....$3.50
**3" FLEX SECT.** sq. flange to Circ. Flange Adapt $7.50
724 **TR TUBE** (41 TR 1) ..... $2.50
**SWR MEAS. SECTION, & L with 2 type "N"** output probes MTD full wave apart. Bell size guide. Silver plated .....$10.00
**ROTARY JOINT** with slotted section and type "N" output pickup .....$17.50
**WAVEGUIDE SECTION,** 12" long choke to cover 45 deg. twist & 2½" radius, 90 deg. bend $4.50
**SLUG TUNER/ATTENUATOR,** W. E. guide, gold plated .....$6.50
**TWIST** 90 deg. 5" choke to Cover w/press nipple .....$6.50
**WAVEGUIDE SECTIONS** 2½ ft: long silver plated with choke flange .....$5.75
**ROTARY JOINT** choke to choke with deck mounting .....$17.50
**3 cm. mitred elbow** "E" plane unplated $6.50 ea
**TS-108A/P DUMMY LOAD** .....$65.00
**3 CM. HORN AT-48/UP** model 710. Type "N" input Hvy. silver plated ..... $6.50
**AT-68/UP** 3 CM Horn with type N fitting $5.00

**SCR 584** SPARE PARTS AVAILABLE

APS 4 AIRBORNE RADAR
Complete sets and various components available.

## 1.25 CENTIMETER

**"K" BAND DIRECTIONAL COUPLER** CU104/APS-34 20 DB ..... $49.50 ea
**"K" BAND FEEDBACK TO PARABOLA HORN,** with pressurized window .. ... .....$30.00
**MITRED ELBOW** cover to cover ..... $4.00
**TR/ATR SECTION** choke to cover .....$4.00
**FLEXIBLE SECTION** 1" choke to choke ... $5.00
**ADAPTER,** rd. cover to sq. cover .... $5.00
**MITRED ELBOW** and S sections choke to cover $4.50
**WAVE GUIDE ½ x ¼ per ft.** .....$1.00
**K BAND CIRCULAR FLANGES** ..... 50¢
**3J31 "K" BAND MAGNETRON** ..... $55.00

## TEST EQUIPMENT

### MODEL TS-268/U

**Test set designed to provide a means of rapid checking of crystal diodes IN21, IN21A, IN21B, IN23, 'N23A, IN23B. Operates on 1½ volt dry cell battery. 3x6x7.**
New ..... $35.00

**10CM ECHO BOX CABV** 14ABA-1 of OBU-3, 2890 MC to 3170 MCS direct reading micrometer head. Ring prediction scale plus 9% to minus 9%. Type "N" input. Resonance indicator meter. New and Comp. w/access. Box and 10 CM Directional Coupler . ...$350.00

**3 CM RECEIVER,** SO-3. Complete with W.G. Mixer Assy (723-A/B). Reg. Fil. Power Supply 6 stages IF (6AC7) .....$99.50

**10 cm. horn assembly** consisting of two 5" dishes with dipoles feeding single type "N" output. Includes UG28/U type "N" "T" junction and type "N" pickup probe. Mfg. cable. New .....$5.56 ea.

**10 cm. cavity** type wavemeters 6" deep, 6½" in diameter. Coax. output. Silver plated .....$64.50 ea.

**10 cm. echo box.** Part of SFI Radar W/115 volt DC tuning motor Sub Sig 1118AO ....$47.50

**THERMISTOR BRIDGE:** Power meter 1-203-A. 10 cm. mfg. W.E. Complete with meter, interpolation chart, portable carrying case .....$72.50

**W.E. 1 138.** Signal generator. 2700 to 2900 Mc. range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input reg. Pwr. supply. With circuit diagram ....$150.00

**3 cm. wavemeter.** Ordnance type micrometer head. New: Absorbtion type .....$85.00
Transmition type .....$92.50

**SL. wavemeter.** Type CW60ABM .....$125.00

**TS 235** UP Dummy Load .. .....$87.50

**TS 89/AP Voltage Divider.** Ranges 100: ½ for 2000 to 20000v. 10:1 for 200 to 2000v. Input Z 2000 ohms. Output Z 4 meg ohms flat response 150 cy to 5 meg cy ..... .. $42.50

**10 cm Wavemeter.** WE type B 435490 Transmission type. Type N Fittings. Veeder Root Micrometer dial, Gold Plated W/Calib. Chart. P/o Freq. Meter X66404A. New .....$99.50

### Complete Radars Available

SO1 Used .....$1200 00
SO13 Used .....$1200 00
SE New .....$1200 00
SFI New .....$2800 00
SCR 533 Trailer unused ..... $ 950.00
CXBR Beacon Used .....$1500 00
CPN3 Beacon Used .....$1500 00
APS4
APS15 Major Components .....$ 500.00
Airborne Radar Altimeter .....$ 175.00

ALL MERCHANDISE GUARANTEED. MAIL ORDERS PROMPTLY FILLED. ALL PRICES F.O.B. NEW YORK CITY. SEND MONEY ORDER OR CHECK ONLY. SHIPPING CHARGES SENT C.O.D. RATED CONCERNS SEND P. O. MERCHANDISE SUBJECT TO PRIOR SALE

**COMMUNICATIONS EQUIPMENT CO.**
131 "I II" Liberty St., New York, N.Y. Cable "Comsupo" Ph. Digby 9-4124

# MAGNETRONS – RADAR – PULSE EQUIPMENT

### MAGNETRONS

| Tube | Frq. Range | Pk. Pwr. Out | Price |
|---|---|---|---|
| 2J31 | 2820-2860 mc. | 265 KW. | $25.00 |
| 2J21-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 2J22 | 3267-3333 mc. | 265 KW. | $25.00 |
| 2J26 | 2992-3019 mc. | 275 KW. | $25.00 |
| 2J27 | 2965-2992 mc. | 275 KW. | $25.00 |
| 2J32 | 2780-2820 mc. | 285 KW. | $25.00 |
| 2J37 | | | $45.00 |
| 2J38 Pkg. | 3249-3263 mc. | 5 KW. | $35.00 |
| 2J39 Pkg. | 3267-3333 mc. | 87 KW. | $35.00 |
| 2J40 | 9305-9325 mc. | 10 KW. | $65.00 |
| 2J49 | 9000-9160 mc. | 58 KW. | $85.00 |
| 2J34 | | | $55.00 |
| 2J61 | 3000-3100 mc. | 35 KW. | $65.00 |
| 2J62 | 2914-3010 mc. | 35 KW. | $65.00 |
| 3J31 | 24,000 mc. | 50 KW. | $55.00 |
| 5J30 | | | $39.50 |
| 713AY | | | $25.00 |
| 718DY | 2720-2890 mc. | 250 K.W. | $25.00 |
| 720BY | 2800 mc. | 1000 KW. | $50.00 |
| 720CY | 2860 mc. | 1000 K.W. | $50.00 |
| 725-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 730-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 728 | AY, BY, CY, DY, EY, FY, GY | | $50.00 |
| 700 | A, B, C, D | | $50.00 |
| 706 | AY, BY, DY, EY, FY, GY | | $50.00 |
| Klystrons. | 723A/B $12.50: W/Cavity 417A $25.00 | 707B 2K41 | $20.00 $65.00 |

### MAGNETRON MAGNETS

| Gauss | Pole Diam. | Spacing | Price |
|---|---|---|---|
| 4850 | ¾ in. | ⅝ in. | $12.50 |
| 5200 | 21/32 in. | ¾ in. | $17.50 |
| 1300 | 1⅝ in. | 1 5/16 in. | $12.50 |
| 1860 | 1⅝ in. | 1½ in. | $14.50 |

**Electromagnets for magnetrons** .... .$24.50 ea.

**GE Magnets** type M7765115, GI Distance Between pole faces variable. 2 1/16" (1900 Gauss) to 1½" (2200 Gauss) Pole Dia. 1⅝" New Part of SCR 584 .... $34.50

### TUNABLE PKGD. "CW" MAGNETRONS

**QK 61** 2975-3200 mc. **QK 62** 3150-3375 mc.
**QK 60** 2800-3025 mc. **QK 59** 2675-2900 mc.
**New, Guaranteed** .....Each $65 00
**QK 915** Raytheon .....$150.00

**Fil Trans** for above 115v 60 cy Pri Four 6.3v/4A Sec: 5000VT .....$27.50
**Magnetronkit.** of four QK's 2675-3375 mc W/ trans. Special .....$250.00

**BC 1277A** Sig. Generator .....$300 00
**APR4.** Receiver 300-2000 mc. .....$475.00
**CPD 10137** Dehydrating Unit .....$425.00

## TELEPHONE EQUIPMENT

### F.T. & R. 101-A APPLIQUE

Provides necessary balancing facilities for four wire repeater when used on two wire lines which may be voice-frequency telephone lines of open wire, or non-loaded or loaded cable. Std. 19" channel from rack mtg. Price, new, complete with tech manual .....$54.00

### SB-19/GT CONSOLE

Provides facilities for patching and monitoring network of lines for telephone intercom, radio reception, telegraph reception, recording, etc. Complete central office supervising position $350.00

### BC 686 LINE AMPLIFIER

With magneto ringer, 3-tube 25L6 amplifier. For local point-to-point telephone operation, remote operation of Phone Xmtr. remove reception of receiver output, monitoring facility. Requires only 24 vdc for tube "B" plus supply for full operation.
New, less tubes, in wooden chest .....$18.50
Per pair for 2-way pt-to-pt operation ...$35.00

### R. F. EQUIPMENT

**LHTR. LIGHTHOUSE ASSEMBLY.** Part of RT-39/APG-5 & APG-15. Receiver and Transmitter Lighthouse Cavities with assoc. Tr. Cavity and Type N CPLG. To Rcvr. Uses 2C40, 2C43, 1B27. Tuneable APX 2400-2700 MCS. Silver plated ..... $49.50
**Receiver transmitter.** Rt-39A/APG-5 10 cm. gun laying RF package using 2C40 and 2C43, new .....$150.00 ea.
**APS-2 10CM RF HEAD COMPLETE WITH HARD TUBE** (715B) Pulser, 714 Magnetron 417A Mixer all ⅞" rigid coax. incl. rcvr. front end ..... $210.00
**Beacon lighthouse cavity 10 cm** with miniature 28 volt DC FM motor. Mfg Bernard Rice ..... $47.50 ea.
**T-128/APN-19 10 cm. radar Beacon transmitter package,** used, less tubes $59.50 ea
**SO-3 "X" band 3 cm RF package,** new complete, including receiver unit as illustrated on Page 337, Volume 23 RAD LAB Series ..... .....$375 00 ea
**Pre-amplifier cavities** type "M" 7410590GL to use 446A lighthouse tube. Completely tunable Heavy silver plated construction $37.50 ea
**RT32/APS 6A RF HEAD.** Compl. with 725A Magnetron magnet pulse xfmr. TRA-ATR. 723 A/B local osc. and beacon mount, pre amplifier. Used but exc. cond. ..... $97.50
**AN/APS-15A** "X" Band compl. RF head and modulator, incl. 725-A magnetron and magnet, two 723A/B klystrons (local osc. & beacon), 1B24, TR, rcvr-ampl. duplexer, HV supply, blower, pulse xtmr. Peak-Pwr Out: 45 KW apx. Input: 115, 400 cy. Modulator pulse duration .5 to 2 micro-sec. apx. 13 KV Pk Pulse. Compl. with all tubes incl. 715-B,829B, RKR 73, two 72's. Compl. pkg., new .$210.00
**"S"BAND AN/APS-2.** Complete RF head and modulator, including magnetron and magnet, 417-A mixer, TR, receiver, duplexer, blower, etc., and complete pulser. With tubes, used, fair condition .....$75.00
**10 CM, RF Package.** Consists of: SO Xmtr.-receiver using 2J27 magnetron oscillator. 250 KW peak input. 707-B receiver-mixer .$150.00

### 200 MC COAXIAL PLUMBING

**Right Angle Bend** .....$35.00
**T Section** .....$55.00
**T Section** with Adapter to ⅞" in rigid coax ..... $65.00

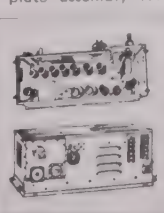
5CM.

**2" x 1" RT. ANGLE BEND CHOKE** TO COVER. SILVER PLATER .....$38 50
**WAVEGUIDE MIXER** CV-12A/APR-6 ....$55.00
**RAPID W. G. FASTENING CLAMPS** .....$5.00

**AN/APG2 Servo Amplifier less tubes, new** .....$35.00

### SUPER SONICS

**QCU Magneto** striction head RCA type CR 278225. New .....$75.00
**Stainless Steel** streamlining housings for above ..... $18 50
**QBG Driver Amplifier.** New .....$200.00
**QCU Magneto** striction head coil plate assembly, new .....$14.50
**QCQ—2/QCB Magneto** striction head coil plate assembly .....$14.50



**3 CM RECEIVER**
SO-3. Complete With W.G. Mixer Assy (723 A/B Reg. Fil. Power Supply, 6 Stages IF 6AC7) ..... $99.50

### CRYSTAL DIODES

| No. | Each | 2 for | 10 for |
|---|---|---|---|
| IN21 | $1.00 | $1.79 | $ 8.30 |
| IN22 | 1.50 | 2.79 | 14.00 |
| IN23 | 1.50 | 2.79 | 14.00 |
| IN26 | 3.00 | 5.90 | 27.50 |

### PULSE EQUIPMENT

**MIT. MOD. 3 HARD TUBE PULSER:** Output Pulse Power: 114 KW (12 KV at 12 amp.). Duty Ratio: .001 max. Pulse duration: 5. 1.0 2.0 microsec. input voltage: 115 v. 400 to 2400 cps. Uses 1-715-B, 1-829-B, 3-'72's, 1-'73. New .....$110.00
**APQ-13 PULSE MODULATOR.** Pulse Width .5 to 1.1 Micro. Sec. Rep. rate 624 to 1348 Pps. Pk. pwr. out 35 KW. Energy 0.018 Joules ..... $49.00
**TPS-3 PULSE MODULATOR.** Pk. power 50 amps. 24 KV (1200 KW pk): pulse rate 200 PPS, 1.5 microsec., pulse line impedance 50 ohms. Circuit—series charging version of DC Resonance type. Uses two 705-A's as rectifiers. 115 v. 400 cycle input. New with all tubes .....$49.50
**APS-10 MODULATOR DECK** Complete, less tubes .....$75.00
**APS-10** Low voltage power supply, less tubes .....$18.50

### PULSE TRANSFORMERS

**G.E.K.-2745** .....$39.50
**G.E.K.-2744-A.** 11.5 KV High Voltage, 3.2 KV Low Voltage @ 200 KW oper. (270 KW max.) 1 microsec. or ¼ microsec. @ 600 PPS $39.50
**W.E. #D166173** Hi-Volt input transformer, W.E. Impedance ratio 50 ohms to 900 ohms. Freq. range: 10 kc to 2 mc. 2 sections parallel connected, potted in oil ..... $36.00
**W.E. KS** 9800 Input transformer. Winding ratio between terminals 3-5 and 1-2 is 1.1:1, and between terminals 6-7 and 1-2 is 2:1. Frequency range: 380-520 c.p.s. Permalloy core ..... $6.00
**G.E. #K2731** Repetition Rate: 635 PPS, Pri. Imp: 50 Ohms. Sec. Imp: 450 Ohms. Pulse Width: 1 Microsec. Pri. Input: 9.5 KV PK. Sec. Output: 28 KV PK. Peak Output: 800 KW. Riflar 2.75 Amp. .. .....$64.50
**W.E. #D169271** Hi Volt input pulse Transformer .....$27.50
**G.E. K2450A.** Will receive 13KV. 4 micro-second pulse on pri., secondary delivers 14KV. Peak power out 100KW G.E. ..... $4.50
**G.E. #K2748A.** Pulse Input, line to magnetron ..... $36.00
**#9280 Utah** Pulse or Blocking Oscillator XFMR Freq. limits 790-810 cy-3 windings turns ratio 1:1:1 Dimensions 1 13/16 x 1⅛" 19/32 . $1.50
**Pulse** 131-AWP L-421435 .....$6.00
**Pulse** 134-BW-2F L-440895 .....$2.25
**358-2754** .....$18.50

### PULSE NETWORKS

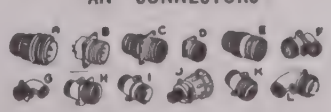
**15A**—1-400-50: 15 KV, "A" CKT, 1 microsec., 400 PPS, 50 ohms imp. .....$42.50
**G.E. #6E3-5-2000-50P2T,** 6KV, "E" circuit, 3 sections, .5 microsecond, 2000 PPS, 50 ohms impedance .....$6.50
**G.E. #3E** (3-84-810; 8-2.24-405) 50P4T; 3KV, "E" CKT Dual Unit: Unit 1, 3 Sections. .84 Microsec.
**810 PPS,** 50 ohms imp.: Unit 2, 8 Sections, 2.24 microsec. 405 PPS. 50 ohms imp. .....$6.50
**7.5E3-1-200-67P.** 7.5 KV, "E" Circuit, 1 microsec. 200 PPS. 67 ohms impedance, 3 sections $7.50
**7.5E4-16-60.67P.** 7.5 KV, "E" circuit, 4 sections, 16 microsec. 60 PPS, 67 ohms impedance $15.00
**7.5E3-3-200-6PT.** 7.5 KV, "E" Circuit, 3 microsec. 200' PPS. 67 ohms imp., 3 sections ....$12.50

### DELAY LINES

**D-168184:** .5 microsec. up to 2000 PPS, 1800 ohm term. .....$4.00
**D-170499:** .25/.50/.75. microsec. 8 KV. 50 ohms imp. .....$16.50
**D-165997:** 1¼ microsec. .....$7.50
**163169** Delay Line. Small quantity available ..... $50.00

UG TYPE CONNECTORS
FULL LINE OF UG CONNECTORS
IN STOCK. IMMEDIATE DELIVERY.

**"AN" CONNECTORS**



LARGE VARIETY AVAILABLE
AT GREAT SAVINGS
Send your specs and let us quote

ALL MERCHANDISE GUARANTEED. MAIL ORDERS PROMPTLY FILLED. ALL PRICES F.O.B. NEW YORK CITY. SEND MONEY ORDER OR CHECK ONLY. SHIPPING CHARGES SENT C.O.D. RATED CONCERNS SEND P. O. MERCHANDISE SUBJECT TO PRIOR SALE

**COMMUNICATIONS EQUIPMENT CO.**
131 "I 11" Liberty St., New York, N.Y. Cable "Comsupo" Ph. Digby 9-4124

SA SC SD SE SF SG SL SN S01 S03 S08 S09 S013 SQ SU TAJ TBK TBL TBM APG5 APR APS2 APS3 APS4 APS6 APS10 APS15 ABA QBF QBG QCQ WEA RAK CPN3 CPN6 DAB RC145 RC148 YD ZA

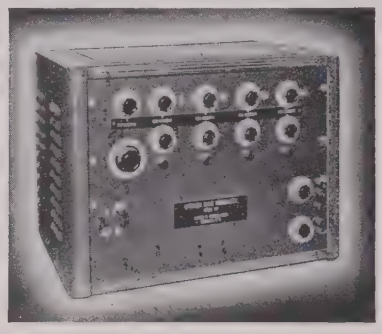
# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 65A)*

## Wave Generator

A new instrument, completely self-contained and power line operated, known as a Complex Wave Generator, Model 57, has been made available by **Alfred W. Barber Labs.,** 34-04 Francis Lewis Blvd., Flushing, L. I., N. Y.

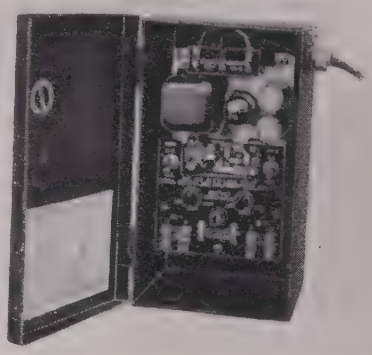


The instrument will provide a fundamental and 2nd, 3rd, 4th, and 5th harmonics in any percentage and any relative phase. The frequency of the fundamental may be varied from 0 to 100 per cent of the fundamental. The phase of any harmonic may be varied through 360 degrees. The fundamental and all harmonics are derived from the same two beating oscillators. Phase shifting is done at a single frequency by means of simple, substantially linear phase shifting circuits.

The manufacturer claims that the Complex Wave Generator has proved itself in the rapid solution of many problems which "hitherto were attacked in a very laborious manner."

## Electronic Relay Switches for Automatic Controls and Gaging Devices

**Coral Designs,** P.O. Box 248, Forest Hills, N. Y., makes available a line of electronic switches that provide the means of using simple contact closure units as "off-on," two-position, three-position, or floating-type controllers to solve pressure, torque, position, movement, and other gaging problems.

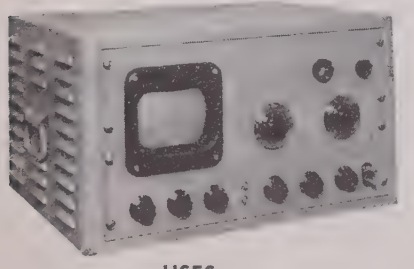


Contact ratings may be obtained for controlling 5 amperes, 10 amperes, or 35 amperes at 115 Volts ac. Adjusting knobs provide operation of the probe resistance to values as high as 500,000 ohms. Operating voltage of all units is 115 volts (±10 per cent) 60 cycles ac. Each unit employs but one tube with replacement life of 10,000 hours. Dust proof and explosion proof units are available for hazardous locations.

## Wide-Range Power Oscillator

A new wide-range power oscillator has been developed by **Airborne Instruments Laboratory, Inc,** 160 Old Country Rd., Mineola, L. I., N. Y., for measurement and testing procedures in the 300- to 2,500-Mc range.

The Type 124A Power Oscillator consists of a grid separation coaxial oscillator employing a 2uc38 disk seal triode, an audio oscillator and modulator section, and a self-contained rectifier power supply. Cathode-grid and grid-plate lines are coupled to a single tuning control with provision for individual adjustment of the grid cathode line, if desired. Counter type indicators show the position of the tuning elements. An output coupling control with counter indicator is also provided.

*Available Now!*

Easy, Fast

Ultrasonic Spectrum Analysis

WITH

MODEL SB-7

PANORAMIC

ULTRASONIC ANALYZER

**An invaluable new direct reading instrument for simplifying ultrasonic investigations, the SB-7 provides continuous high speed panoramic displays of the frequency, amplitude and characteristics of signals between 2KC and 300KC. The SB-7 allows simultaneous observation of many signals within a band up to 200KC wide. Special control features enable selection and highly detailed examination of narrower bands which may contain signals separated by less than 500c.p.s. The instrument is unique in that it provides rapid indications of random changes in energy distribution.**

USES

- Ultrasonic Vibration Measurements
- Harmonic Analysis
- Cross Modulation Studies
- Noise Investigations
- Determining Transmission Characteristics of Lines and Filters
- Monitoring Communications Carrier Systems
- Checking Interference, Spurious Modulation, Parasitics, Effects of load changes, shock, humidity, component variations, etc. upon frequency stability
- Telemetering

SPECIFICATIONS

Frequency Range: 2KC—300KC, stabilized linear scale

Scanning Width: Continuously variable from 200KC to zero

Four Input Voltage Ranges: 0.05V. to 50V. Full scale readings from 1 millivolt to 50 volts

Amplitude Scale: Linear and two decale log

Amplitude Accuracy: Within 1db. Residual harmonics suppressed by at least 50db.

Resolution. Continuously variable. 2KC at maximum scanning width, 500c.p.s. for scanning widths below 8KC.

*WRITE NOW For Complete Information, Price and Delivery*

PANORAMIC RADIO PRODUCTS INC.

12 SOUTH SECOND AVE MOUNT VERNON, N. Y.

# Positions Wanted

*(Continued from page 58A)*

ELECTRONIC ENGINEER

B.S. (Physics/Math) February 1949. Married, two children. Graduate CREI 2 years experience test and research. 2 years experience Navy radio technician. 3 years experience Broadcast radio engineer 1st class Radiotelephone license. Amateur License. Box 365 W.

ELECTRONIC ENGINEER

Electronic engineer, M.E.E. 2 years research and development experience in servomechanisms electronics and radar technique plus laboratory instruction in electrical engineering and Navy radar experience. Top scholastic record, Tau Beta Pi, Eta Kappa Nu. Box 369 W

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 22A)*

## DC Driven DC-AC Chopper

A recent addition to the line of dc-ac choppers manufactured by **Stevens-Arnold Inc.**, 22 Elkins St., South Boston. Mass. is a dc driven type.

This self-excited chopper is an electromechanical vibrator to be used as a modulator, rectifier demodulator, or square-wave generator. This design was arranged for those applications where dc is preferred to ac as the source of coil excitation Actually it is a combination of an SPDT and an SPST chopper.

*(Continued on page 63A)*

## Recent Catalogs

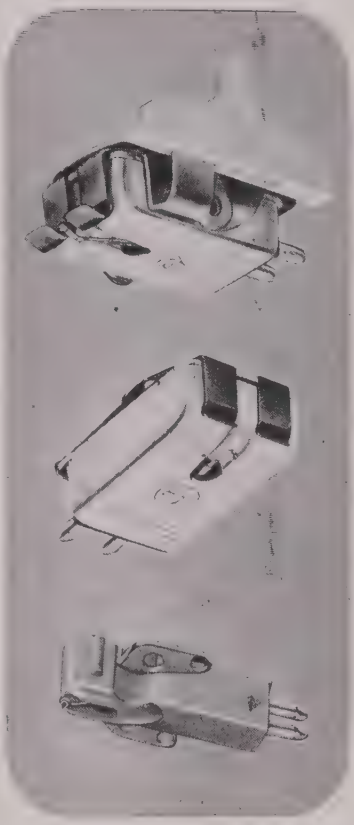
• • • A new booklet describing the advantages and new applications of vacuum coating chambers for industrial purposes has been printed by **Vacuum Equipment Div., Distillation Products, Inc.**, 755 Ridge Rd. W., Rochester 13, N. Y.

• • • The 1950 Twin-Trax catalog, a 16-page listing of more than 30 new tape recorders, is obtainable from **Twin-Trax Div., Amplifier Corp. of America**. 398-1 Broadway, New York 13, N. Y


EVERYTHING you want..

- TAILORED FREQUENCY RESPONSE
- HIGHER COMPLIANCE
- LOWER MECHANICAL IMPEDANCE
- HIGHER VOLTAGE-COMPLIANCE PRODUCT
- IMPROVED TRACKING
- LOW DISTORTION TORQUE DRIVE
- LOWER STYLUS FORCE

with E-V Modern Phono Cartridges



**Dual Needle** The Twilt, proven in thousands of high quality receivers, tracks perfectly at six grams in *all* grooves and speeds. E-V's inline twin tips provide higher compliance (softness of needle touch to record) at three mil tip . . . where it is needed for playing 78 RPM records without weight change. Twin-tilt cartridges are available with a standard frequency response or can be made to your response specifications.

**Single Needle** For one or three mil grooves. Stylus easily replaceable. Response tailored to your specific needs. TORQUE DRIVE* gives higher voltage and compliance product. Choice of snap-in or rigid mounting.

**Universal Needle** A compromise stylus that will give satisfactory service on both three mil and one mil records. Minimum tracking force only eight grams. Frequency response made to your requirements.

The *Universal Needle* is the result of months of intensive research and an alert product development program.

• Higher compliance than hitherto obtainable from old style crystal harnessing is an inherent characteristic of TORQUE DRIVE, exclusive to all E-V cartridges. Multiplication of stylus force produces a higher product of voltage and compliance. Accurate frequency response standards are maintained in QUANTITY PRODUCTION because all pads, bearings and high parallel compliances are eliminated. Special E-V SILICONE moisture-proofing gives the crystal many times greater protection against humidity than normal moisture treatment . . . considerably increasing cartridge life.

• *E-V single play tone arms are built to the same exacting standards as E-V cartridges. Arm dimensions permit excellent tracking across any size record. Feedback from base-board to cartridge is reduced because of scientific tone arm design.*

**Patent Pending*

ELECTRO-VOICE, INC., BUCHANAN, MICH. Export: 13 East 40th St., New York 16, U.S.A. Cables: Arlab

NO FINER CHOICE THAN Electro-Voice

CRYSTAL AND MAGNETIC PHONO PICKUPS • CRYSTAL, DYNAMIC, CARBON AND VELOCITY MICROPHONES • STANDS AND ACCESSORIES

# *TWIN* Power Supply

***Electronically Regulated for Precise Measurements***

Two independent sources of continuously variable D.C. are combined in this one convenient unit. Its double utility makes it a most useful instrument for laboratory and test station work. Three power ranges are instantly selected with a rotary switch:

175-350 V. at 0-60 Ma., terminated and controlled independently, may be used to supply 2 separate requirements.
0-175-V. at 0-60 Ma. for single supply.
175-350 V. 0-120 Ma. for single supply.

In addition, a convenient 6.3 V.A.C. filament source is provided. The normally floating system is properly terminated for external grounding when desired. Adequately protected against overloads.

- *Output voltage variation less than 1% with change from 0 to full load.*
- *Output voltage variation less than 1 V. with change from 105 to 125 A.C. Line Voltage.*
- *Output ripple and noise less than .025 V.*

Twin Power Supply Model 210
Complete $130.00
Dimensions: 16" X 8" X 8" Shipping Wt. 35 lbs.
(Other types for your special requirements)

**FURST ELECTRONICS**
14 S. Jefferson St., Chicago 6, Illinois

---

***Available Now!***

## Easy, Fast Ultrasonic Spectrum Analysis WITH MODEL SB-7

## PANORAMIC ULTRASONIC ANALYZER

**USES**

- Ultrasonic Vibration Measurements
- Harmonic Analysis
- Cross Modulation Studies
- Noise Investigations
- Determining Transmission Characteristics of Lines and Filters
- Monitoring Communications Carrier Systems
- Checking Interference, Spurious Modulation, Parasitics, Effects of load changes, shock, humidity, component variations, etc. upon frequency stability
- Telemetering

**SPECIFICATIONS**

Frequency Range: 2KC—300KC stabilized linear scale

Scanning Width: Continuously variable from 200KC to zero

Four Input Voltage Ranges: 0.05V to 50V F.S. scale readings from 1 millivolt to 50 volts

Amplitude Scale: Linear and two decade log

Amplitude Accuracy: Within 1db. Residual harmonics suppressed by at least 50db

Resolution: Continuously variable. 2KC at maximum scanning width, 500c.p.s. for scanning widths below 8KC

***WRITE NOW For Complete Information, Price and Delivery***

**An invaluable new direct reading instrument for simplifying ultrasonic investigations, the SB-7 provides continuous high speed panoramic displays of the frequency, amplitude and characteristics of signals between 2KC and 300KC. The SB-7 allows simultaneous observation of many signals within a band up to 200KC wide. Special control features enable selection and highly detailed examination of narrower bands which may contain signals separated by less than 500c.p.s. The instrument is unique in that it provides rapid indications of random changes in energy distribution**

PANORAMIC RADIO PRODUCTS Inc. MOUNT VERNON, N. Y.

---

ANNOUNCING A NEW 8" SPEAKER WITH A NEW HARD-HITTING RANGE

**JIM LANSING SIGNATURE**

## 8" SPEAKER

**100 TO 12,000 C. P. S.**

WHERE QUALITY REPRODUCTION IS A "MUST" and space is at a premium—the Jim Lansing 8" Speaker answers the problem! High efficiency and good over-all performance. For improved radio, phonograph and custom television sound reproduction. Designed especially for commercial or industrial use. Ideal for music distribution and paging systems. At all better dealers and distributors.

MODEL D-1002
Two-Way System

For FM monitoring and high quality home sound reproduction. Console type cabinet.

*See your Jobber or write to:*

**JAMES B. LANSING SOUND INC.**
2439 Fletcher Drive
Los Angeles, California

HIGH CAPACITY TO SPACE RATIO

*With Johnson Pressurized Capacitors*

JOHNSON Pressurized Capacitors are so carefully engineered that they provide the desired capacity and voltage rating with minimum pressure and condenser height. Because of their efficient electrical and mechanical design, they also provide the utmost in stable operating conditions.

Available as "standard" are variable, fixed and fixed-variable units — in a wide variety of capacitance and current rating. In addition, JOHNSON can build any pressure condenser to individual specifications.

**FEATURES**

- Low Loss
- High KVA Rating
- Shielded From External Electrostatic Fields
- Low Internal Distributed inductance
- Complete Dependability

*Write For Illustrated JOHNSON Catalog and Prices*

JOHNSON

*a famous name in Radio!*

E. F. JOHNSON CO. WASECA, MINN.

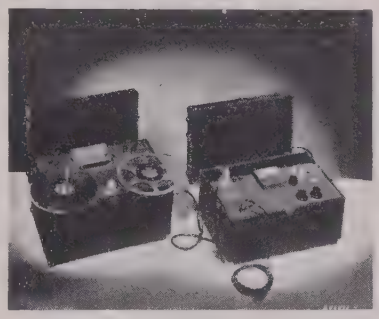

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 61A)*

## Portable Magnetic Tape Recorders

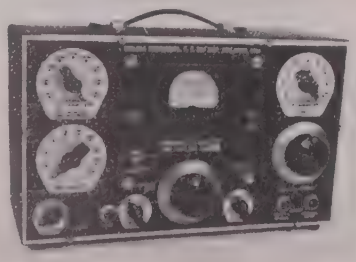
Two new portable professional models of Ekotape magnetic tape recorders, Model 105, consisting of a single unit contains both record and playback amplifiers in addition to the magnetic tape recorder mechanism, Model 107, consisting of two units, the recording mechanism and the amplifier chassis, are announced by **Webster Electric Co.**, Racine, Wis.



Both models are provided with a single knob control for record, stop, listen, and rewind. The synchronous two-speed motor of Model 107, shown in illustration, provides a tape speed of 15 inches per second for a full half-hour program, or a tape speed of 7½ inches per second for an hour program. Tape speed of 7½ inches per second with Model 105 provides for a full half-hour program. Fast forward and fast rewind speeds permit rapid selection and replay of any part of a recording without removing the tape reels.

## DC Amplifier and Millivoltmeter

A new dc amplifier and millivoltmeter, Model DCA-3, with a sensitivity of 1 mv and 165 micromicroamperes for full-scale deflection, has been developed by **Millivac Instruments**, P.O. Box 3027, New Haven, Conn.



The DCA-3 has a direct input impedance of 6 megohms—16 and 60 with a multiplier. The input impedance selector operates between 100 ohms to 4 megohms parallel burden. There is an output shunt selector—1 to 1,000 ohms parallel burden, or protection of sensitive external meters.

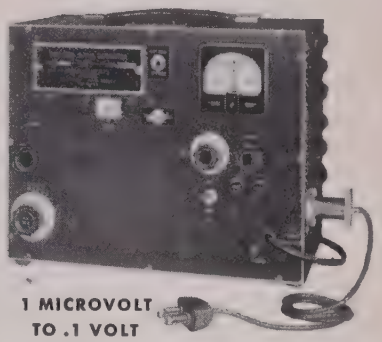
Maximum dc output is 5 milliamperes, sufficient for ink and photographic recorders.

*(Continued on page 64A)*


FM SIGNAL GENERATORS

MODEL 78-FM

*86 Mc.—108 Mc.*



1 MICROVOLT TO .1 VOLT

**DEVIATION:** Directly calibrated dial. Two ranges, 0 to 30 kc., 0 to 300 kc. Internal 400 cycle oscillator. Can also be modulated from external source.

**DIMENSIONS:** 10"x13"x7". Weight 20 lbs.

**POWER SUPPLY:** 117 volts, 50-60 cycles. 36 watts.

**● SPECIAL GENERATORS**

One-band Model 78-FM generators, with a tuning ratio of approximately 1.2 to 1, are available for use within the limits of 30 to 165 megacycles.

MODEL M-275

I. F. CONVERTER

*For Use With Model 78-FM.*

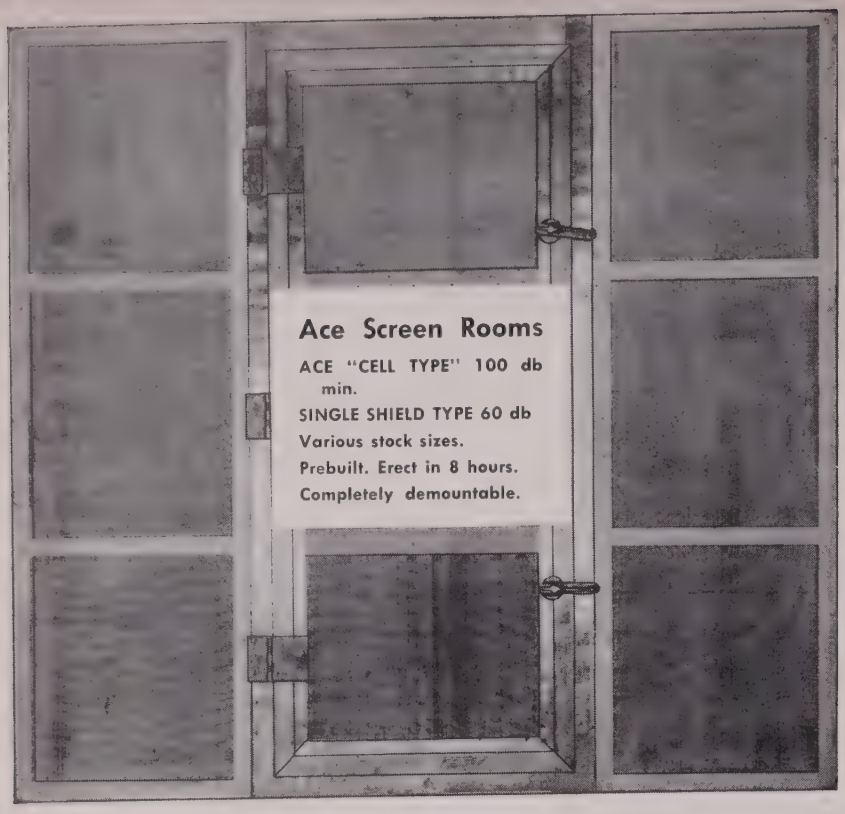
**CARRIER FREQUENCIES:** 4.5 Mc.; 10.7 Mc.; 21.7 Mc. (Provision for one extra frequency).

**OUTPUT:** When used with Model 78-FM the output voltage is variable from 10 microvolts to 1 volt.

**POWER SUPPLY:** 117 volts, 50-60 cycles, 45 watts.

MEASUREMENTS CORPORATION

BOONTON NEW JERSEY




Ace Screen Rooms

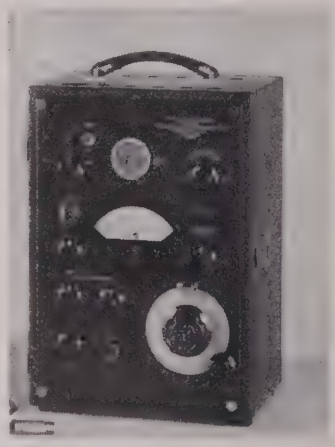
ACE Engineering & Machine Co.

3644 N. Lawrence St. Philadelphia 40, Pa.

NOW AVAILABLE!

A Z-ANGLE METER FOR RADIO FREQUENCY MEASUREMENTS

Featuring the same ease and efficiency of operation as the widely used audio Z-Angle Meter, the new R-F Z-Angle Meter simplifies the problem of measurements at radio frequencies of broadcast antennas, transmission lines, complex networks and impedance elements.



Write today for bulletins on other T. I. C. products: Z-Angle Meter . . . R-F Oscillator . . . Electronic Phase Meter . . . Precision Linear and Non-Linear Variable Resistors . . . Translatory Variable Resistors . . . Slide Wire Resistance Boxes.

Frequency Range: 100 kc to 2 mc
Direct Reading:
Impedance Range: 10 to 5,000 ohms up to 200 kc
10 to 1,000 ohms up to 1 mc
Phase Angle: +90° ($X_L$) thru 0° (R) to −90° ($X_c$)
Q Range: 0.2 to 10
Portable—for field or laboratory use
Self-contained balance indicator
Operates at high level—overrides extraneous antenna pickup

TECHNOLOGY INSTRUMENT CORP.
1058 MAIN STREET, WALTHAM 54, MASS.

ENGINEERING REPRESENTATIVES

Chicago, Ill.—STate 2-7444 Cambridge, Mass.—ELiot 4-1751 Canaan, Conn.—Canaan 649
Rochester, N.Y.—Charlotte 3193-J Dallas, Tex.—Logan 6-5097

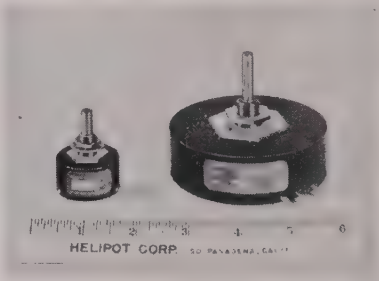
# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 63A)*

## Two New Precision Linear Potentiometers

Two new potentiometers, Models F and G, with guaranteed linearity accuracies of ±0.5 per cent, and 1.0 per cent respectively are being manufactured by **Helipot Corp.**, South Pasadena 6, Calif.




With the Model F, by substitution, it is possible to obtain accuracies of 0.1 per cent, and in the higher values of resistance 0.05 per cent. All ratings of the Model G are held within linearity tolerances of ±1.0 per cent, and in the higher resistances to accuracies of ±0.25 per cent.

Both models have been tested in excess of a million revolutions at speeds as high as 100 rpm. Slide wire and slip ring contacts are of precious metal alloys. Resistance values of both models are held within ±5 per cent, but can be maintained at tolerances as low as ±1 per cent, if required.

## Dynaural Converter

Based upon the H. H. Scott Dynamic Noise Suppressor, a new line of equipment for Dynaural reproduction of music, particularly from phonograph records has been developed by **Hermon Hosmer Scott, Inc.**, 385 Putnam Ave., Cambridge 39, Mass.

In a Dynaural system the bandwidth is automatically and continuously adjusted to conform with the requirements of the music, thus combining maximum fidelity with minimum noise level.

The first unit available is the Type 111-A Dynaural Converter. Designed for use with standard amplifiers, phonographs and combinations, it has a 14 kc range.

Simplicity of installation and operation have been stressed in the design of the Dynaural Converter, which requires only two connections. A single remote Dynaural control is provided with a special dial plate and bracket for mounting on the panel of the phonograph, in the phonograph compartment, or any other convenient location.

*(Continued on page 65A)*

# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

*(Continued from page 64A)*

## New Model Direct Coupled Amplifier

The Type 112 dc amplifier, with a bandwidth of 1 Mc when used at a maximum gain of 5,000 volts, is obtainable on order from **Taktronix, Inc.,** 712 S.E. Hawthorne Blvd., Portland 14, Ore.

For gain requirements of 166 volts or less, the bandwidth extends to 2 Mc. An output of approximately 150 volts (peak to peak) is available to a high impedance load such as cathode-ray tube deflection plates. Control of gain is continuously variable from 0.5 to 5,000 volts by use of a step and variable attenuator.

The amplifier has an input impedance of 1 megohm—45 $\mu\mu f$ each side to ground, or 10 megohms—14 $\mu\mu f$ each side to ground when using the supplied probes.

A 1 kc square wave calibrating voltage from 0 to 50 volts is available by a nine position range switch in conjunction with a calibrated potentiometer providing an accuracy of $\pm 5$ percent.

## New Electrosensitive Recording Paper

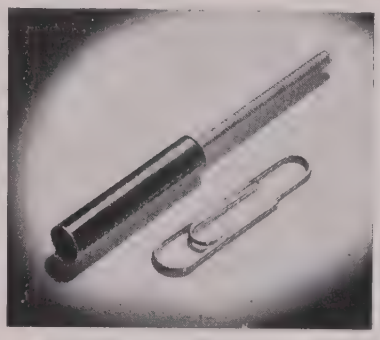
Designed for use with Helix-type recorders, and applicable to record radar, sonar, and infrared signals, computer totals, and telemetered dispatch, a new electrosensitive paper is available from **Alfax Paper and Engineering Co.,** 46 Riverside Ave., Brockton, Mass.

The manufacturer has stated that when using a Helix-type and Alfax paper, inertia-free instantaneous recording at speeds to 300 inches per second and up are available. With this inkless, permanent paper, recording of four simultaneous overlapping signals is accomplished with no difficulty.

## New Cores For TV Image Width Control

Molded of a powdered material assuring high permeability, these iron cores have been designed for television horizontal image deflection circuits by **Electronic Components Div., Stackpole Carbon Co.,** St. Marys, Pa.

In screen areas where there is a sudden voltage drop, the manufacturer claims that these cores give ratios of from 1 to 8 or more, compared to 1 to 5 for previous high permeability cores.



Known as Stackpole Ceramag II cores, the new units are of standard screw-type construction and are available in a complete range of frequencies for modern television applications.

*(Continued on page 68A)*

*A.R.C.'s VHF Communication and Navigation Equipment is a*

**REVELATION**

Get static-free communication and the added reliability of omni range navigation with A. R. C.'s Type 17 2-way VHF Communication and Type 15B Omni Range Navigation Equipment. With the 15B tuned to VHF omni stations, you fly directly in less time. You can receive weather broadcasts simultaneously with navigation signals **—static free!** It simplifies navigation and gives long, trouble-free life. The Type 17 adds an independent communication system for use while the 15B is providing navigational information. Installations for both single and multi-engined planes are made only by authorized agencies.

**CLEAR COMMUNICATION ON VHF**

All A.R.C. airborne equipment is Type Certificated by CAA. It is designed for reliability and performance—not to meet a price. Write for further details or name of your nearest A.R.C. representative.

ARC

**Aircraft Radio Corporation**

BOONTON, NEW JERSEY

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tell you what they make, in your IRE Yearbook. Products are organized in 68 easy-to-use, fundamental engineering groups. It saves you time and money to "look it up" in your IRE Yearbook!

Distributed to 17,291 IRE Member Engineers

# R. F. COMPONENTS–MICROWAVE–TEST EQUIPMENT

## 10 CENTIMETER

**WAVEGUIDE TO 7/8" RIGID COAX "DOOR-KNOB" ADAPTER. CHOKE FLANGE. SILVER PLATED BROAD BAND** .....$37.50

**WAVEGUIDE DIRECTIONAL COUPLER,** 27 db. Navy type CABV-47AAN, with 4 in. slotted section .....$32.50

**SQ. FLANGE** to rd choke adapter, 18 in. long OA 1½ in. x 3 in. guide, type "N" output and sampling probe .....$27.50

**Crystal Mixer** with tunable output TR pick up loop, Type "N" connectors. Type 62ABH .....$14.50

**Slotted line probe.** Probe depth adjustable, Sperry connector, type CPR-14AAO ..$9.50

**Coaxial slotted section,** 5/8" rigid coax with carriage and probe .....$25.00

**Right Angle Bend** 6" radius E or H plain $15.00

**Right Angle Bend** 3" radius E or H plain—Circular flanges .....$15.00

**AN/APR5A** 10 cm antenna equipment consisting of two 10 CM waveguide sections, each polarized, 45 degrees .....$75.00 per set

**APN-7 TR McNally Cavity** for 707B, with tuning slugs .....$5.50 ea.

**"S" Band Crystal Mount,** gold plated, with 2 type "N" connectors .....$12.50

**PICKUP LOOP,** Type "N" Output .....$2.75

**TR BOX** Pick-up Loop .....$1.25

**POWER SPLITTER:** 726 Klystron input dual "N" output .....$5.00

**MAGNETRON TO WAVEGUIDE** coupler with 721-A duplexer cavity, gold plated ..$27.50

**10 CM WAVEGUIDE SWITCHING UNIT,** switches 1 input to any of 3 outputs. Standard 1½" x 3" guide with square flanges. Complete with 115 vac or dc arranged switching motor. Mfg. Raytheon. CRP 24AAS. New and complete .....$150.00

**"S" BAND** Mixer Assembly, with crystal mount, pick-up loop, tunable output .....$3.00

**721-A TR CAVITY WITH TUBE.** Complete with tuning plungers .....$12.50

**10 CM. McNALLY CAVITY** Type SG ...$3.50
Type SF .....$4.50

**WAVEGUIDE SECTION,** MC 445A, rt. angle bend, 5½" ft. OA. 8" slotted section ..$21.00

**10 CM OSC. PICKUP LOOP,** with male Homedell output .....$2.00

**10 CM DIPOLE WITH REFLECTOR** in lucite ball, with type "N" or Sperry fitting ..$4.50

**10 CM FEEDBACK DIPOLE ANTENNA,** in lucite ball, for use with parabola 7/8" Rigid Coax Input .....$8.00

**PHASE SHIFTER.** 10 CM WAVEGUIDE, WE TYPE ES-683816. E PLANE TO H PLANE MATCHING SLUGS .....$95.00

**721A TR cavities.** Heavy silver plated $2.00 ea.

**10 cm. horn and rotating** joint assembly, gold plated .....$65.00 ea.

## 7/8" RIGID COAX—3/8" I.C.

**7/8" rigid coaxial tuning stubs** with vernier stub adjustment. Gold Plated .....$17.50

**7/8 RIGID COAX ROTARY JOINT.** Pressurized, Sperry #810613. Gold Plated .....$27.50

Dipole assembly. Part of SCR-584 ....$25.00 ea.

Rotary joint. Part of SCR-584 .....$35.00 ea.

**RIGHT ANGLE BEND,** with flexible coax output pickup loop .....$8.00

**SHORT RIGHT ANGLE BEND,** with pressurizing nipple .....$3.00

**RIGID COAX** to flex coax connector .....$3.50

**STUB-SUPPORTED RIGID COAX,** gold plated 5' lengths. Per length .....$5.00

**RT. ANGLES** for above .....$2.50

**RT. ANGLE BEND 15" L. OA** .....$3.50

**FLEXIBLE SECTION,** 15" L. Male to female .....$4.25

**FLEX COAX SECT.** Approx. 30 ft. .....$16.50

## 7/8" RIGID 1/4" IC

**CG 54/U**—4 foot flexible section 1/4" IC pressurized .....$15.00

7/8 RIGID COAX. Bead Supported .....$1.20

**SHORT RIGHT ANGLE BEND** .....$2.50

Rotating joint, with deck mounting ... $15.00

RIGID COAX slotted section CU-60/AP $5.00

## WAVEGUIDE

| | |
|---|---|
| ½" x ¼" ID | $1.00 per foot |
| 1" x ½" OD | 1.50 per foot |
| ⅝" x 1¼" OD | 1.65 per foot |
| ⅝" x 1¼" OD Aluminum | .75 per foot |
| 1½" x 3" OD | 3.00 per foot |
| 2½" x 3" OD | 3.50 per foot |
| 1" x ½" OD Flexible | 4.00 per foot |
| 7/8" rigid coax ¼" IC | 1.20 per foot |

(Available in 10FT to 15ft. lengths or smaller.)

**UG 65/U** 10CM flanges .....$6.75 each

**UG 53/U** Cover .....4.00 each

**UG 54/U** Choke .....4.50 each

**SCR 584** SPARE PARTS AVAILABLE

## 3 CENTIMETER

**(STD. 1" x ½" GUIDE UNLESS OTHERWISE SPECIFIED)**

**723 A/B Klystron mixer section** with crystal mount, choke flange and Iris flange output .....$22.50

**TR-ATR Section** for above with 724 ATR Cavity $8.50

**Cutler 105/APS31 Directional Coupler** 25 DB .....$25.00

**90 degree twist,** 6 inches long .....$8.00

**723 AB Mixer**—Beacon Dual Oscillator Mount with Crystal holder .....$12.00

**2 Way Wave Guide directional coupler,** type N fitting 1⅛" x ⅝" guide 26DB .....$18.50

**CG 98B/APG 13,** 12" flexible section 1¼" x ⅝" OD .....$10.00

**TR-ATR Section,** APS 15, for 1B24, with 724 ATR Cavity with 1B24 and 724 tubes. Complete $21.00

**Crystal mount** in waveguide .....$17.50

**SO-3 Echo box,** Xmsn. type cavity w/ bellows .....$28.50

**3 cm. 180° bend with pressurizing nipple** $6.00 ea.

**3 cm. 90 bend,** 14" long 90° twist with pressurizing nipple .....$6.00 ea.

**3 cm.** "S" curve 18" long.....$5.50 ea.

**3 cm.** "S" curve 6" long .....$3.50 ea.

**3 cm. right angle bends.** "E" plane 18" long cover to cover .....$6.50 ea.

**3 cm. Cutler feed dipole.** 11" from parabola mount to feed back .....$8.50 ea.

**TWIST** 45 deg., 6" long .....$8.00

**APS-31 mixer section** for mounting two 2K25's. Beacon reference cavity 1B24 TR tube. New and complete with attenuating slugs $42.50 ea.

**DUPLEXER SECTION** for 1B24 .....$10.00

**CIRCULAR CHOKE FLANGES,** solid brass .55

**SQ. FLANGES, FLAT BRASS** .....ea. .55

**FLEX. WAVEGUIDE** .....$4.00/Ft.

**TRANSITION** 1 x ½ to 1¼ x ⅝, 14 in. ..$8.00

**"X" BAND PREAMPLIFIER,** consisting of 2-723 A/B local oscillator-beacon feeding waveguide and **TR/ATR** Duplexer sect. incl. 30MC Pre Amp with tubes .....$67.50

**Random Lengths wavegd,** 6" to 18" Lg. $1.10/Ft.

**WAVEGUIDE RUN.** 1¼" x ½" guide, consisting of 4 ft. section with Rt. angle bend on one end 2" 45 deg. bend other end ..$8.00

**WAVEGUIDE RUN, 1¼" x ½" guide,** consisting of 4 ft. long .....$10.00

**12" SECTION** 45 deg twist, 90 deg bend $6.00

**11" STRAIGHT WAVEGUIDE** section choke to cover. Special heavy Construction, silver plated .....$4.50

**15 DEG BEND** 10" choke to cover .....$4.50

**5 FT. SECTIONS choke to cover,** Silver Plated $10.00

**18" FLEXIBLE SECTION** .....$17.50

**"X" BAND WAVEGUIDE** 1¼" x ⅝" OD 1/16" wall Alluminum .....Per Foot $ .75

**WAVEGUIDE** 1" x ½" I.D. .....Per Foot $1.50

**TR CAVITY** For 724 A TR Tube .....$3.50

**3" FLEX SECT.** sq. flange to Circ. Flange Adapt $7.50

**724 TR TUBE** (41 TR 1) .....$2.50

**SWR MEAS. SECTION, with 2 type "N"** output probes MTD full wave apart. Bell sizes guide. Silver plated .....$10.00

**WAVEGUIDE SECTION,** 12" long choke to cover 45 deg. twist & 2½" radius, 90 deg. bend $4.50

**SLUG TUNER/ATTENUATOR,** W. E. guide, gold plated .....$6.50

**TWIST** 90 deg. 5" choke to Cover w/press nipple .....$6.50

**WAVEGUIDE SECTIONS** 2½ ft: long silver plated with choke flange .....$5.75

**ROTARY JOINT** choke to choke .....$17.50

**ROTARY JOINT** choke to choke with deck mounting .....$17.50

UG TYPE CONNECTORS
FULL LINE OF UG CONNECTORS
IN STOCK. IMMEDIATE DELIVERY.

## "AN" CONNECTORS

**LARGE VARIETY AVAILABLE**
**AT GREAT SAVINGS**
Send your specs and let us quote

## 1.25 CENTIMETER

**"K" BAND DIRECTIONAL COUPLER** CU104/APS-34 20 DB .....$49.50 ea.

**"K" BAND FEEDBACK TO PARABOLA HORN,** with pressurized window .....$30.00

**MITRED ELBOW** cover to cover .....$4.00

**TR/ATR SECTION** choke to cover .....$4.00

**FLEXIBLE SECTION** 1" choke to choke ....$5.00

**ADAPTER,** rd. cover to sq. cover ....$5.00

**MITRED ELBOW** and S sections choke to cover $4.50

**WAVE GUIDE** ½ x ¼ per ft. .....$1.00

**K BAND CIRCULAR FLANGES** .....50¢

**3J31 "K" BAND MAGNETRON** .....$55.00

## TEST EQUIPMENT

**MODEL TS-268/U**

**Test set designed to provide a means of rapid checking of crystal diodes IN21, IN21A, IN21B, IN23, 'N23A, IN23B. Operates on 1½ volt dry cell battery. 3x6x7.**

New .....$35.00

## CRYSTAL DIODES

| No. | Each | 2 for | 10 for |
|---|---|---|---|
| IN21 | $1.00 | $1.79 | $ 8.30 |
| IN22 | 1.50 | 2.79 | 14.00 |
| IN23 | 1.50 | 2.79 | 14.00 |
| IN26 | 3.00 | 5.90 | 27.50 |

**10CM ECHO BOX CABV** 14ABA-1 of OBU-3, 2890 MC to 3170 MCS direct reading micrometer head. Ring prediction scale plus 9% to minus 9%. Type "N" input. Resonance indicator meter. New and Comp. w/access. Box and 10 CM Directional Coupler .. ...$350.00

**3 CM RECEIVER,** SO-3. Complete with W.G. Mixer Assy (723-A/B). Reg. Fil. Power Supply 6 stages IF (6AC7) .....$99.50

**10 cm. horn assembly** consisting of two 5" dishes with dipoles feeding single type "N" output. Includes UG28/U type "N" "T" junction and type "N" pickup probe. Mfg. cable. New .....$15.50

**10 cm. cavity** type wavemeters 6" deep, 6½" in diameter. Coax. output. Silver plated .....$64.50 ea.

**10 cm. echo box.** Part of SFI Radar W/115 volt DC tuning motor Sub Sig 1118AO ...$47.50

**THERMISTOR BRIDGE:** Power meter 1-203-A. 10 cm. mfg. W.E. Complete with meter, interpolation chart, portable carrying case .....$72.50

**W.E. 1 138.** Signal generator. 2700 to 2900 Mc. range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input reg Pwr. supply. With circuit diagram ....$150.00

**3 cm. wavemeter.** Ordnance type micrometer head. New: Absorbtion type .....$85.00
9000-9500 MCS Transmition type .....$92.50

**SL. wavemeter.** Type CW60ABM .....$125.00

**TS 89/AP Voltage Divider.** Ranges 100: ½ for 2000 to 20000v. 10:1 for 200 to 2000v. Input Z 2000 ohms. Output Z 4 meg ohms flat response 150 cy to 5 meg cy .....$42.50

**10 cm Wavemeter.** WE type B 435490 Transmission type. Type N Fittings. Veeder Root Micrometer dial, Gold Plated W/Calib. Chart. P/o Freq. Meter X66404A. New .....$99.50

**AS14A/AP**—10cm Pick up Dipole with "N" Cables .....$4.50

**TS 235 UP** Dummy Load .....$87.50

## COMPLETE RADARS AVAILABLE

| | |
|---|---|
| SOI Used | $1200.00 |
| SOI3 Used | $1200.00 |
| SE New | $1200.00 |
| SFI New | $2800.00 |
| SCR 533 Trailer unused | $950.00 |
| CXBR Beacon Used | $1500.00 |
| CPN3 Beacon Used | $1500.00 |
| APS4 | |
| APS15 Major Components | $500.00 |
| Airborne Radar Altimeter | $175.00 |

ALL MERCHANDISE GUARANTEED. MAIL ORDERS PROMPTLY FILLED. ALL PRICES F.O.B. NEW YORK CITY. SEND MONEY ORDER OR CHECK ONLY. SHIPPING CHARGES SENT C.O.D. RATED CONCERNS SEND P. O. MERCHANDISE SUBJECT TO PRIOR SALE

**COMMUNICATIONS EQUIPMENT CO.**

131 "I 12" Liberty St., New York, N.Y. Cable "Comsupo" Ph. Digby 9-4124

# MAGNETRONS – RADAR – PULSE EQUIPMENT

### PULSE EQUIPMENT

**MIT. MOD. 3 HARD TUBE PULSER:** Output Pulse Power: 114 KW (12 KV at 12 amp.). Duty Ratio: .001 max. Pulse duration: 5, 1.0 2.0 microsec. input voltage: 115 v. 400 to 2400 cps. Uses 1-715-B, 1-829-B, 3-'72's, 1-'73. New . . . . . $110.00

**APQ-13 PULSE MODULATOR.** Pulse Width .5 to 1.1 Micro. Sec. Rep. rate 624 to 1348 Pps. Pk. pwr. out 35 KW. Energy 0.018 Joules $49.00

**TPS-3 PULSE MODULATOR.** Pk. power 50 amps. 24 KV (1200 KW pk): pulse rate 200 PPS, 1.5 microsec., pulse line impedance 50 ohms. Circuit—series charging version of DC Resonance type. Uses two 705-A's as rectifiers 115 v. 400 cycle input. New with all tubes $49.50

**APS-10 MODULATOR DECK** Complete, less tubes . . . . $75.00

**APS-10** Low voltage power supply, less tubes . . . . . $18.50

### PULSE TRANSFORMERS

**G.E.K.-2745** . . . . $39.50

**G.E.K.-2744-A.** 11.5 KV High Voltage, 3.2 KV Low Voltage @ 200 KW oper. (270 KW max.) 1 microsec. or ¼ microsec. @ 600 PPS $39.50

**W.E. ‡D166173** Hi-Volt input transformer. W.E Impedance ratio 50 ohms to 900 ohms. Freq range: 10 kc to 2 mc, 2 sections parallel connected potted in oil . . . . . $36.00

**W.E. KS** 9800 Input transformer. Winding ratio between terminals 3-5 and 1-2 is 1.1:1, and between terminals 6-7 and 1-2 is 2:1. Frequency range: 380-520 c.p.s. Permalloy core . . . . . $6.00

**G.E. ‡K2731** Repetition Rate: 635 PPS, Pri. Imp 50 Ohms. Sec. Imp: 450 Ohms. Pulse Width: 1 Microsec. Pri. Input: 9.5 KV PK. Sec. Output: 28 KV PK. Peak Output: 800 KW Riflar 2.75 Amp. . . . . $64.50

**W.E. ‡D169271** Hi Volt input pulse Transformer . . . . . $27.50

**G.E. K2450A.** Will receive 13KV. 4 micro-second pulse on pri., secondary delivers 14KV Peak power out 100KW G.E. . . . . $4.50

**G.E. ‡K2748A.** Pulse Input, line to magnetron . . . . . $36.00

**‡9280 Utah** Pulse or Blocking Oscillator XFMR Freq. limits 790-810 cy-3 windings turns ratio 1:1:1 Dimensions 1 13/16 x 1⅛" 19/32 $1.50

**Pulse** 131-AWP L-421435 . . . . . $6.00

**Pulse** 134-BW-2F L-440895 . . . . . $2.25

### PULSE NETWORKS

**15A**—1-400-50: 15 KV, "A" CKT, 1 microsec., 400 PPS, 50 ohms imp. . . . . $42.50

**G.E. ‡6E3-5-2000-50P2T,** 6KV. "E" circuit, 3 sections, .5 microsecond, 2000 PPS, 50 ohms impedance . . . . . $6.50

**G.E. ‡3E** (3-84-810; 8-2.24-405) 50P4T; 3KV, "E" CKT Dual Unit: Unit 1, 3 Sections. .84 Microsec.

**810 PPS,** 50 ohms imp.: Unit 2, 8 Sections, 2.24 microsec. 405 PPS, 50 ohms imp. . . . . $6.50

**7.5E3-1-200-67P.** 7.5 KV, "E" Circuit, 1 microsec. 200 PPS, 67 ohms impedance, 3 sections $7.50

**7.5E4-16-60.67P.** 7.5 KV, "E" circuit, 4 sections, 16 microsec. 60 PPS, 67 ohms impedance $15.00

**7.5E3-3-200-6PT.** 7.5 KV, "E" Circuit, 3 microsec. 200' PPS, 67 ohms imp., 3 sections . . $12.50

### DELAY LINES

**163169** Delay Line Small quantity available . . . . . $50.00

**D-168184:** .5 microsec. up to 2000 PPS 1800 ohm term. . . . . $4.00

**D-170499:** .25/.50/.75. microsec. 8 KV. 50 ohms imp. . . . . $16.50

**D-165997:** 1¼ microsec. . . . . $7.50

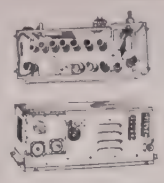
### THERMISTORS

**D-167332** (tube) . . $.95
**D-170396** (bead) . $.95
**D-167613** (button) $.95
**D-164600** for MTG in "X" band Guide $2.50
**D-167018** (tube) . . $.95

### VARISTORS

| | |
|---|---|
| D-170225 | $1.25 |
| D-167176 | $.95 |
| D-168687 | $.95 |
| D-171812 | $.95 |
| D-171528 | $.95 |
| D-168549 | $.95 |
| D-162482 | $3.00 |
| D-163298 | $1.25 |
| D-99428 | $2.00 |
| D-161871A | $2.85 |
| D-171121 | $.95 |
| 3A(12-43) | $1.50 |
| D-167020 | $3.00 |

***WRITE FOR C.E.C. MICRO-WAVE CATALOG NOW AVAILABLE***



### 3 CM RECEIVER

**SO-3.** Complete With W.G. Mixer Assy (723 A/B Reg. Fil Power Supply, 6 Stages IF 6AC7) . . . . . $99.50

### MAGNETRONS

| Tube | Frq. Range | Pk. Pwr. Out | Price |
|---|---|---|---|
| 2J31 | 2820-2860 mc. | 265 KW | $25.00 |
| 2J21-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 2J22 | 3267-3333 mc. | 265 KW. | $25.00 |
| 2J26 | 2992-3019 mc. | 275 KW. | $25.00 |
| 2J27 | 2965-2992 mc. | 275 KW. | $25.00 |
| 2J32 | 2780-2820 mc. | 285 KW. | $25.00 |
| 2J37 | | | $45.00 |
| 2J38 Pkg. | 3249-3263 mc. | 5 KW. | $35.00 |
| 2J39 Pkg. | 3267-3333 mc. | 87 KW. | $35.00 |
| 2J40 | 9305-9325 mc. | 10 KW. | $65.00 |
| 2J49 | 9000-9160 mc. | 58 KW. | $85.00 |
| 2J34 | | | $55.00 |
| 2J61 | 3000 3100 mc. | 35 KW. | $65.00 |
| 2J62 | 2914-3010 mc. | 35 KW. | $65.00 |
| 3J31 | 24.000 mc. | 50 KW | $55.00 |
| 5J30 | | | $39.50 |
| 714AY | | | $25.00 |
| 718DY | 2720-2890 mc. | 250 K.W. | $25.00 |
| 720BY | 2800 mc. | 1000 KW. | $50.00 |
| 720CY | 2860 mc. | 1000 K.W. | $50.00 |
| 725-A | 9345-9405 mc. | 50 KW | $25.00 |
| 730-A | 9345-9405 mc | 50 KW. | $25.00 |
| 728 | AY, BY, CY, DY, EY, FY, GY | | $50.00 |
| 700 | A, B, C, D | | $50.00 |
| 706 | AY, BY, DY, EY, FY, GY | | $50.00 |
| Klystrons. | 723A/B $12.50: 707B W/Cavity | | $20.00 |
| | 417A $25.00 | 2K41 | $65.00 |

### MAGNETRON MAGNETS

| Gauss | Pole Diam. | Spacing | Price |
|---|---|---|---|
| 4850 | ¾ in. | ⅝ in. | $12.50 |
| 5200 | 21/32 in. | ¾ in. | $17.50 |
| 1300 | 1⅝ in. | 1 5/16 in. | $12.50 |
| 1860 | 1⅝ in. | 1½ in. | $14.50 |

**Electromagnets for magnetrons** . . . $24.50 ea

**GE Magnets** type M7765115, GI Distance Between pole faces variable. 2 1/16" (1900 Gauss) to 1½" (2200 Gauss) Pole Dia. 1⅝" New Part of SCR 584 . . . . . $34.50

### "CW" MAGNETRONS

QK 62 3150-3375 mc.
QK 59 2675-2900 mc.
QK 61 2975-3200 mc.
QK 60 2800-3025 mc.

**New, Guaranteed Each $65.00**
**QK 915** Raytheon . . $150.00

**Fil Trans** for above 115v 60 cy Pri Four 6.3v/4A Sec: 5000VT . . . . . $27.50

**Magnetronkit.** of four QK's 2675-3375 mc W/ trans. Special . . . . . $250.00

### SUPER SONICS

**QCU Magneto** striction head RCA type CR 278225. New . . . . . $75.00

**Stainless Steel** streamlining housings for above . . . . . $18.50

**QBG Driver Amplifier.** New . . . . . $200.00

**QCU Magneto** striction head coil plate assembly, new . . . . . $14.50

**QCQ—2/QCB Magneto** striction head coil plate assembly . . . . . $14.50

**APS 4 AIRBORNE RADAR**
Complete sets and various components available.

**AS-17/APS**—10cm. Airborne Antenna complete with all plumbing, dish, etc. . . . . $89.50

**SCR 584** SPARE PARTS AVAILABLE

**AN/APG2** Servo Amplifier less tubes new $35.00

### R. F. EQUIPMENT

**LHTR. LIGHTHOUSE ASSEMBLY.** Part of RT-39/APG-5 & APG-15. Receiver and Transmitter Lighthouse Cavities with assoc. Tr. Cavity and Type N CPLG. To Rcvr. Uses 2C40, 2C43, 1B27 Tuneable APX 2400-2700 MCS. Silver plated . . . . . $49.50

**APS-2 10CM RF HEAD COMPLETE WITH HARD TUBE** (715B) Pulser, 714 Magnetron 417A Mixer all ⅞" rigid coax, incl. rcvr. front end . . . . . $210.00

**Beacon lighthouse cavity 10 cm** with miniature 28 volt DC FM motor. Mfg Bernard Rice . . . . . $47.50 ea

**T-128/APN-19 10 cm. radar Beacon transmitter package,** used, less tubes $59.50 ea

**SO-3 "X" band 3 cm RF package,** new complete, including receiver unit as illustrated on Page 337, Volume 23 RAD LAB Series . . . . . $375.00 ea.

**Pre-amplifier cavities** type "M" 7410590GL to use 446A lighthouse tube. Completely tunable. Heavy silver plated construction $37.50 ea

### RT32/APS 6A RF HEAD

Compl. with 725A Magnetron magnet pulse xfmr. TRA-ATR. 723 A/B local osc. and beacon mount, pre amplifier. Used but exc. cond. $97.50

**AN/APS-15A** "X" Band compl. RF head and modulator, incl. 725-A magnetron and magnet, two 723A/B klystrons (local osc. & beacon), 1B24, TR, rcvr-ampl. duplexer, HV supply, blower, pulse xtmr. Peak-Pwr Out: 45 KW apx. Input: 115, 400 cy. Modulator pulse duration .5 to 2 micro-sec. apx. 13 KV Pk Pulse. Compl. with all tubes incl. 715-B,829B, RKR 73, two 72's. Compl. pkg., new $210.00

**"S" BAND AN/APS-2.** Complete RF head and modulator, including magnetron and magnet, 417-A mixer, TR, receiver, duplexer, blower, etc., and complete pulser. With tubes, used, fair condition . . . . . $75.00

**10 CM, RF Package.** Consists of: SO Xmtr.-receiver using 2J27 magnetron oscillator, 250 KW peak input. 707-B receiver-mixer $150.00

### 200 MC COAXIAL PLUMBING

**Right Angle Bend** . . . . . $35.00
**T Section** . . . . . $55.00
**T Section with Adapter to ⅞" in rigid coax** . . . . . $65.00

### 5CM.

**2" x 1" RT. ANGLE BEND CHOKE TO COVER SILVER PLATER** . . . . . $38.50
**WAVEGUIDE MIXER** CV-12A/APR-6 . . $55.00
**RAPID W. G. FASTENING CLAMPS** . . . . $5.00

**BC 1277A** Sig. Generator . . . . . $300.00
**APR4.** Receiver 300-2000 mc. . . . . $475.00
**CPD 10137** Dehydrating Unit . . . . . $425.00

### TRANSTAT AMERTRAN

Input: 0.115 v. 50-60 cycle. Max., output: 115 v. 100 amp.

All units are new, guaranteed . . . . . $95

**2 KVA:** 90-130 v. input 50-60 cycles output 115 v 2 kva type RH Amertran . . $29.95 each

### WILCOX CS390 CONTROL EQUIPMENT

**FOR AIRPORT CONTROL GROUND STATION**—Standard relay rack housing, monitor loud speaker, dual channel receiver amplifier, Type 109 A control panel, microphone speech amplifier, etc., spare parts, new and complete . . . . . $750.00 each

### BIRTCHER TUBE CLAMPS

| | | |
|---|---|---|
| 926C | 926B-16 | 926-C15 |
| 926-16 | 926A-14 | 926-C-13 |
| 926-B1 | 926A | 926B |
| 926-B2 | 926C1 | 926C-19 |
| 926-B8 | 926-A11 | |
| Each 15c | 10 for $1.40 | 100 for $12.00 |

**CONDENSERS** WE HAVE ONE OF THE LARGEST SELECTIONS OF OIL, ELECTROLYTIC, MICA BATHTUBS, ETC., IN THE COUNTRY AT SURPLUS PRICES. WRITE FOR CATALOGUE.

ALL MERCHANDISE GUARANTEED. MAIL ORDERS PROMPTLY FILLED. ALL PRICES F.O.B. NEW YORK CITY. SEND MONEY ORDER OR CHECK ONLY. SHIPPING CHARGES SENT C.O.D. RATED CONCERNS SEND P. O. MERCHANDISE SUBJECT TO PRIOR SALE

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SO3
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SO9
SO13
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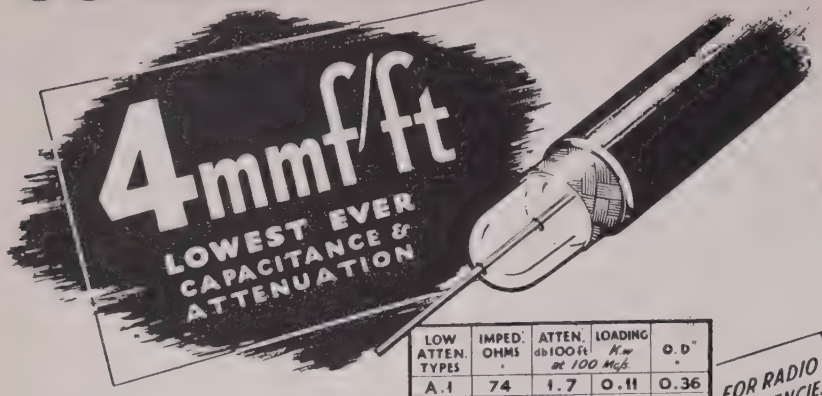
TBK
TBL
TBM
APG5
APR
APS2
APS3
APS4
APS6
APS10
APS15
ABA
QBF
QBG
QCQ
WEA
RAK
CPN3
CPN6
DAB
RC145
RC148
YD
ZA

# CO-AX AIR-SPACED ARTICULATED R.F. CABLES




| LOW ATTEN. TYPES | IMPED. OHMS | ATTEN. db/100 ft. at 100 Mc/s. | LOADING K.w | O.D" |
|---|---|---|---|---|
| A.1 | 74 | 1.7 | 0.11 | 0.36 |
| A.2 | 74 | 1.3 | 0.24 | 0.44 |
| A.34 | 73 | 0.6 | 1.5 | 0.85 |

HIGH POWER FLEXIBLE

FOR RADIO FREQUENCIES

| LOW CAPAC. TYPES | CAPAC. mmf/ft | IMPED. OHMS | ATTEN. db/100 ft. 100 Mc/s. | O.D" |
|---|---|---|---|---|
| C.1 | 7.3 | 150 | 2.5 | 0.36 |
| P.C.1 | 10.2 | 132 | 3.1 | 0.36 |
| C.11 | 6.3 | 173 | 3.2 | 0.36 |
| C.2 | 6.3 | 171 | 2.15 | 0.44 |
| C.22 | 5.5 | 184 | 2.8 | 0.44 |
| C.3 | 5.4 | 197 | 1.9 | 0.64 |
| C.33 | 4.8 | 220 | 2.4 | 0.64 |
| C.44 | 4.1 | 252 | 2.1 | 1.03 |

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VERY LOW CAPACITANCE CABLES

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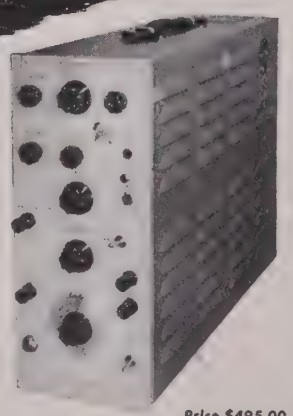
# TEKTRONIX

## DIRECT COUPLED AMPLIFIER

***Band Pass DC - 2 mc***
***Push Pull Throughout***
***Gain .5 to 5000 Continuously Variable***



*The TEKTRONIX **Type 112 Direct-Coupled Amplifier** is presented as a highly desirable auxiliary instrument primarily intended for use with the TEKTRONIX Type 511-A, 511-AD, 512, or other cathode ray oscilloscopes. It consists of the vertical amplifier of the Type 512 Oscilloscope complete with self-contained, fully-regulated power supply and 1 kc. square wave voltage calibrator.*

***Price $495.00***
***f.o.b. Portland, Oregon***

### *ABRIDGED SPECIFICATIONS*

***BAND PASS · · · DC - 2mc. gain 150 or less, DC - 1mc. gain 150 to 5000; VOLTAGE CALIBRATOR · · · 1 Kc. Square wave in nine ranges, .5V. to 50V. full scale. Accuracy ±5%; INPUT CIRCUIT · · · single ended or push-pull, selected by front panel switch; OUTPUT VOLTAGE · · · 150V. to high imp. (CRT), internal imp. 8000 ohms plate to plate; STABILITY · · · Insured by carefully balanced circuitry and use of electronically regulated DC supply to heaters of pre-amp. stages.***

***Detailed Specifications on request.***

TEKTRONIX, INC.

***712 S.E. Hawthorne Blvd. Portland 14, Oregon - EAst 6197 - Cables: Tektronix***


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

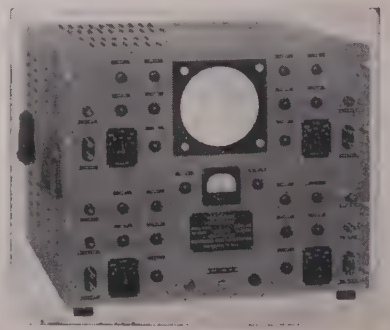
*(Continued from page 65A)*

## HF Noise Generating Diode

A new miniature noise generating diode, suitable for measurements at frequencies up to 500 Mc, has been announced by the Radio Div., **Sylvania Electric Products Inc.**, 500 Fifth Ave.. New York 18, N. Y.

The new T 5½ tube Type 5722 is designed for standard laboratory noise measurement. It is operated with 150 volts on plate and at filament voltages ranging between 2 and 5.5 volts, depending on desired plate current or noise output. In intermittent service, maximum plate dissipation is 5 watts.

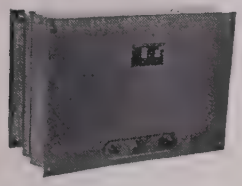
## Record Oscilloscope Displays Four Independent Variables



A single 5-inch cathode-ray tube oscilloscope capable of indicating four separate phenomena simultaneously is currently available from **Electronic Tube Corp.**, 1200 E. Mermaid Lane, Philadelphia 18, Pa.

*(Continued on page 69A)*

# the first line of STANDARD electronic voltage regulators



Sorensen electronic voltage regulators offer accuracy under simultaneous line and load changes.

IMPORTANT SORENSEN FEATURES:

1. Precise regulation accuracy;
2. Excellent wave form;
3. Output regulation over wide input voltage range;
4. Fast recovery time;
5. Adjustable output voltage, that once set, remains constant;
6. Insensitivity to line frequency fluctuations between 50 and 60 cycles.

The Sorensen Catalog contains complete specifications on standard voltage regulators and nobatrons. It will be sent to you upon request.

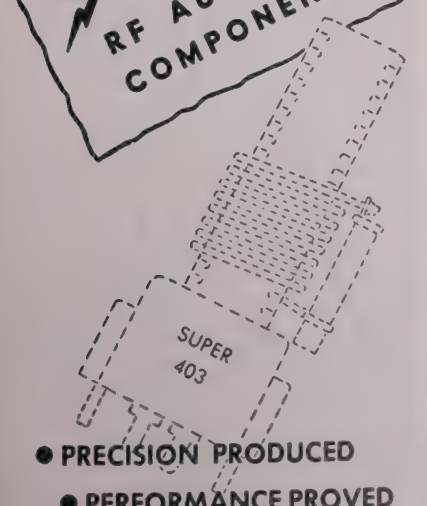
**SORENSEN** & Company, Inc.

*375 Fairfield Ave., Stamford, Conn.*



# NOTE THIS NAME

SUPER RF AUDIO TV COMPONENTS




● PRECISION PRODUCED

● PERFORMANCE PROVED

**SUPER ELECTRIC PRODUCTS CORP.**

*Pacing Electronic Progress With Ingenuity*

**1057 Summit Ave., Jersey City 7, N. J.**


# News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation

*(Continued from page 68A)*

Separate focus, intensity, and positioning controls are provided in each of the four channels, and positioning in both horizontal and vertical directions is possible.

The four signal amplifiers have a frequency range from 0 to 200 kc ± 3 db. and a gain of about 120 times.

Power supplies for the tube and the amplifiers are contained in the cabinet, and require a primary supply of 105-120 volts, 50 to 60 cps.

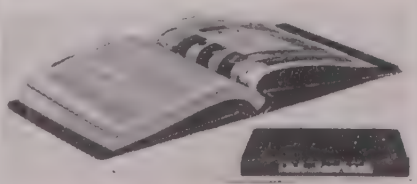
Designated as Model H-43, this oscilloscope is normally supplied with a Fairchild Type, F-246A, Oscillo-Record 35-mm camera, but may be used in conjunction with larger drum type cameras if preferred.

## Microwave Relay System for Industrial Purposes

New commercial microwave relay equipment for high-frequency point-to-point communication systems is now available to industrial users from the designer, RCA Engineering Products Dept., **Radio Corp. of America,** Camden, N. J.

Stations are approximately 35 miles apart, and house two receivers and transmitters for simultaneous two-way operation. The Type CWTR-5A radio relay equipment provides a modulation channel extending from 300 to 30,000 cps, and is designed for unattended operation in the 940- to 960-Mc frequency band. However, by use of the channeling equipment, each radio circuit is capable of carrying four voice conversations simultaneously. Channeling equipment is also available to break each of these voice bands into as many as 16 signaling circuits for telemetering, signalling, or supervisory control functions.

## Yearbook Binder



A permanent, springback binder that snaps onto the IRE YEARBOOK transforming the book into a handsome, bound volume, and that can be transferred to each new annual issue, lasting for years, is offered for $2.75 by **R. V. Metcalf, 52 Chauncy St., Boston 11, Mass.**

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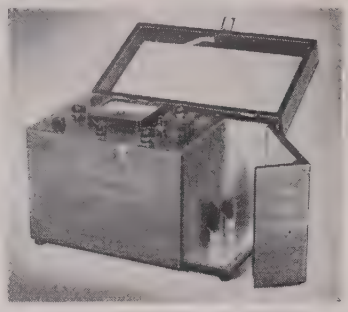

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ATLANTA

"Recent Trends in Oscillography," by M. B. Kline, Allen B. DuMont Laboratories; April 15, 1949.

BALTIMORE

"GCA (Ground Controlled Approach) Past, Present and Future," by C. W. Hicks, Bendix Radio Division; April 26, 1949.

BEAUMONT-PORT ARTHUR

"Prospecting for Petroleum," by A. Winterhalter and J. Millington, Sun Oil Company; February 21, 1949.

"Super-Sensitive Electrical Mechanism," by L. E. Bohrer, Faculty of Lamar College; March 24, 1949.

"Progress in Engineering Science," by C. H. Scarlett, Westinghouse Electric Corporation; April 29, 1949.

"Instruments in Industry," by O. Haultnunen and K. McEntire, General Electric Company; May 4, 1949.

BUFFALO-NIAGARA

"Television Picture Quality," by K. R. Wendt, Colonial Radio Corporation; April 20, 1949.

CEDAR RAPIDS

"Engineering Aspects of the Transistor," and "A New Microwave Tube," by R. M. Ryder, Bell Telephone Laboratories; April 25, 1949.

"Technical Details of the Baldwin Electronic Organ," by A. F. Knoblaugh, Baldwin Company; May 12, 1949.

CHICAGO

"The Relation of the Radio Engineer to his Management and to the Radio Industry," by J. E. Brown, Zenith Radio Corporation; Panel Discussions; March 18, 1949.

"Professionalism and Professional Consciousness—They Grow," by A. Von Praag, National Society of Professional Engineers; Panel Discussions; April 15, 1949.

Election of Officers; May 13, 1949.

CLEVELAND

"Particle Accelerators," by W. P. Simpson, General Engineering Laboratory; April 28, 1949.

"RMA Composite Television Signal," by T. B. Friedman, Television Station KXEL; Nomination of Officers; May 12, 1949.

CONNECTICUT VALLEY

"Traveling-Wave Tubes," by R. Hutter, Sylvania Electric Products; April 21, 1949.

"Improved System of Heterodyne Frequency Measurement," by J. L. Galen, University of Connecticut; "On the Measurement of Piezoelectric Resonator Properties," by G. D. Gordon, Wesleyan University; "A Continuously-Adjustable Filter for Audio Frequencies," by G. E. Tisdale, Yale University; "Electronic Arithmetic," by C. N. Hoyler, RCA Laboratories; Nomination of Officers; May 12, 1949.

New England Radio Engineering Meeting; Annual Outing and election of Officers; May 21, 1949.

DALLAS-FORT WORTH

"Four-Terminal Direct-Coupled Amplifier," by L. W. Erath, Southern Industrial Electronics Research and Development Corporation; April 28, 1949.

*(Continued on page 38A)*


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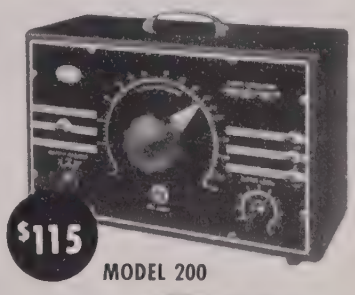

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†Columbia #281 Test Record, 33-1/3 RPM *Audio-tone Test Record, 78 RPM


## SECTION MEETINGS

*(Continued from page 37A)*

DENVER

"Principles of Servomechanicms," by D. S. Stacey, Faculty of University of Colorado; "Demonstration of a Clapp Frequency Stabilized Oscillator," by W. Luebke and C. Goss, Students of University of Colorado; May 11, 1949.

DETROIT

"The Synchrotron—A New Type of Electronic Accelerator," by H. R. Crane, Faculty of University of Michigan; April 15, 1949.

HOUSTON

"Factors Affecting Design of Turnstile Antennas," by G. H. Brown, RCA Laboratories; February 21, 1949.

"Applications of Inverse Feedback," by L. W. Erath, S.I.E. Research and Development Company; March 21, 1949.

"Marine Depth Recorder," by D. E. Stotler, Gulf Radiotelephone Company; April 19, 1949.

"Measurements of Nuclear Radiations," by G. Herzog, The Texas Company; May 12, 1949.

INYOKERN

"Microtime Techniques," by A. Zarem, Stanford Research Institute; April 27, 1949.

"A Device for Admittance Measurements in the 50- to 500-Mc Range," by F. Ireland, General Radio Company; May 18, 1949.

KANSAS CITY

Tour of Midwest Research Institute; April 5,, 1949.

"Television Picture Quality," by R. G. Artman Television Station KMBC; Election of Officers; May 24, 1949.

LOS ANGELES

"Facsimile: Applications and Design," by H. Doeleman, Sierra Engineering; "Nuclear Energy," by A. B. Brown, Graduate Student of California Institute of Technology; "San Diego Yellow Cab Communication System," by H. Grove, West Coast Electronics Company; April 19, 1949.

LOUISVILLE

"Basic Theory of Magnetic Recorders Using AC and DC Bias," by L. L. Anderson; Election of Officers; May 13, 1949.

MILWAUKEE

"Energy Relations in Oscillatory Circuits," by W. E. Richter, Allis Chalmers Company; January 12, 1949.

"Audio Amplifiers and Feedback Considerations," by J. P. Goodell, Minnesota Electronics Corporation; January 18, 1949.

"Waveguides and Magnetrons," by R. O. Kallenberger, Faculty of Marquette University; January 26, 1949.

"Lateral Disk Recording and Reproduction," by N. Pickering, Pickering and Company; February 9, 1949.

"Mechanical and Electrical Analogies," by E. Halbach, Perfex Corporation; February 23, 1949.

"Measurement of Energy of Microwave Frequencies," by W. Hewlett, Hewlett-Packard Company; March 17, 1949.

"The Effect of Stylus Design of Disk Recorded Material," by I. Capps, Frank L. Capps Company; March 29, 1949.

NEW MEXICO

"A Microwave Vibration Analyzer," by H. F. Clarke, Sandia Laboratory; April 22, 1949.

NORTH CAROLINA-VIRGINIA

"The Magic of Microwaves," by R. N. Marshall, Western Electric Company; April 22, 1949.

*(Continued on page 40A)*

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## SECTION MEETINGS

*(Continued from page 38A)*

OMAHA-LINCOLN

"TV, Its Mechanics and Promise," by W. W. Lawrence, RCA Victor Division; October 14, 1949.

OTTAWA

"Transmission of Intelligence by Facsimile," by G. F. Godfrey, Department of National Defense; April 14, 1949.

"Institute Activities," by F. H. R. Pounsett, Stromberg-Carlson Company, Ltd.; May 16, 1949.

PITTSBURGH

"The Transistor—A New Semiconductor Amplifier," by J. A. Becker, Bell Telephone Laboratories; December 13, 1948.

"The Bell Telephone Company and Television," by L. R. Huggler, Bell Telephone Company; January 10, 1949.

"Electron Tube Phonograph Pickup," by J. R Horsch, Student of Carnegie Institute of Technology; "High-Fidelity Phonograph Systems," by H. L. Brenton, Student of Carnegie Institute of Technology; February 14, 1949.

"Ceramics That Talk," by R. E. Stark, Stupakoff Ceramic and Manufacturing Company; March 14, 1949.

"Behind the Scenes in the Broadcasting Business," by T. C. Kenney, Radio Station KDKA; J. Greenwood, Radio Station WCAE; W. W. McCoy, Radio Station WJAS; J. J. Schultz, Radio Station KQV; H. R. Kaier, Radio Station WWSW; April 11, 1949.

"Magnetic Amplifiers," by L. A. Finzi, Faculty of Carnegie Institute of Technology; May 9, 1949.

PORTLAND

"Coaxial Cable Carrier System for Message, Program, and Television Service," by J. M. Roberts, Pacific Telephone and Telegraph Company; April 15, 1949.

"Engineering Books," by A. L. Albert, Faculty of Oregon State College; May 5, 1949.

PRINCETON

Open House; April 28, 1949.

"Old and New Theories of Conduction in Solids," by K. K. Darrow, Bell Telephone Laboratories; Election of Officers; May 12, 1949.

ROCHESTER

"Electron Tube Ratings and Characteristics," by R. L. Kelly, RCA Tube Division; April 21, 1949.

"Some Aspects of Atomic Power Development," by E. H. Bancker, General Electric Company; Election of Officers; May 19, 1949.

SACRAMENTO

"Graphical Solutions," by I. J. Sandorf, Faculty of University of Nevada; March 8, 1949.

"Printed Circuits and Miniature Electronics," by C. Brunetti, Faculty of Stanford Research Institure; April 18, 1949.

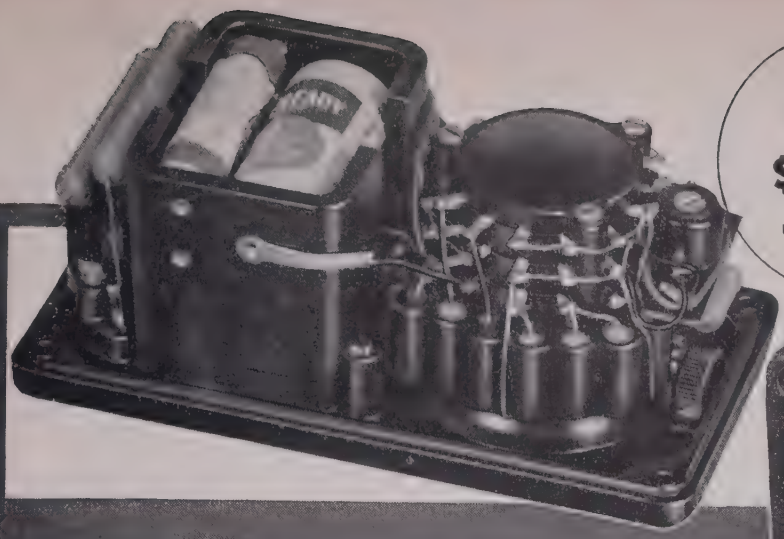
SALT LAKE

"Techniques of Television Servicing," by C. E. Kitto, General Electric Supply Corporation; April 25, 1949.

SAN FRANCISCO

"Low-Noise Figure Traveling-Wave Tubes at Meter and Centimeter Wavelengths," by L. M. Field, Faculty of Stanford University; April 13, 1949.

*(Continued on page 42A)*



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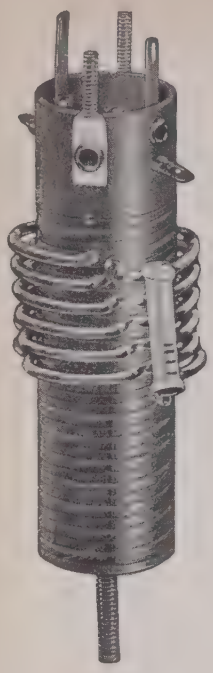

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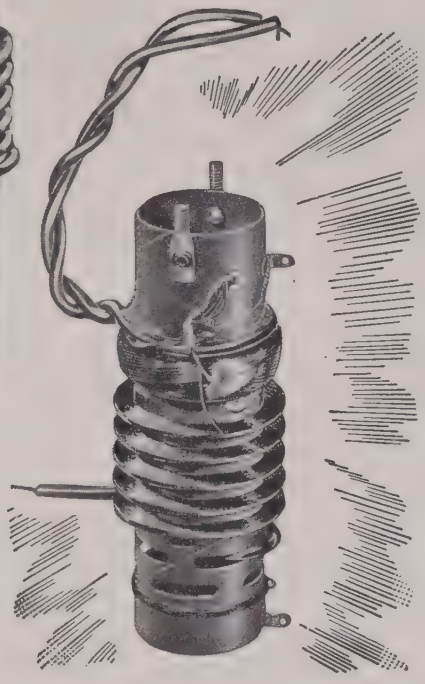

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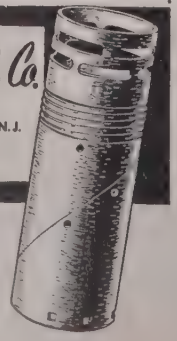

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# Section Meetings

*(Continued from page 40A)*

### SEATTLE

"High-Precision Velocity Servomechanism," by G. Stoner and G. Brown, Boeing Airplane Company; March 25, 1949.

"VHF Omnidirectional Range," by W. R. Triplett, C.A.A. Engineering Division; April 22, 1949.

### SYRACUSE

"Antennas with Circular Symmetry," by W. R. LePage, Faculty of Syracuse University; March 3, 1949.

"Television," by D. W. Pugsley, General Electric Company; Film: Visit to Electronics Park; March 28, 1949.

Film: Atomic Physics; Election of Officers; May 5, 1949.

### TOLEDO

"New Developments in Communications," by R. C. Clark and J. S. Henchel, Ohio Bell Telephone Company; March 14, 1949.

"Designing Directional Broadcast Antenna Arrays," by A. R. Bitter, Consulting Radio Engineer; April 18, 1949.

### TWIN CITIES

"A New Microwave Triode," by R. M. Ryder, Bell Telephone Laboratories; April 28, 1949.

"The Radio Engineer Looks at Industrial Electronics," by E. D. Cook, General Electric Company; April 12, 1949.

"Large-Scale Operational Research in Industry as Illustrated by the Great Lakes Radar Studies," by C. M. Jansky, Jr., and S. L. Bailey, Consulting Engineers; May 9, 1949.

"A System of Remotely Controlled Broadcast Program Circuit Switching," by R. Essig, Collins Radio Company; May 18, 1949.

### WILLIAMSPORT

"Television Trends," by G. C. Larson, Westinghouse Electric Corporation; April 27, 1949.

## *SUBSECTIONS*

### AMARILLO-LUBBOCK

"Ground-Controlled Approach," by J. Bratton, CAA; March 17, 1949.

"Naturally It's FM"; General Electric Film; "FM Broacasting," by E. N. Luddy, Radio Station KFDA-FM; April 18, 1949.

### HAMILTON

Election of Officers; Trip through Bell Telephone Company; April 18, 1949.

### MONMOUTH

"Acoustic Lenses for Audio-Frequency Applications," by W. E. Kock, Bell Telephone Laboratories; May 18, 1949.

"Distortion in Audio Systems," by L. A. DeRosa, Federal Telecommunication Laboratory; April 20, 1949.

### NORTHERN NEW JERSEY

"Natural Frequencies and the Potential Analogue," by W. H. Huggins, RF Components Laboratory, Air Matériel Command, Cambridge Field Station; April 13, 1949.

"Development and Performance of Television Camera Tubes," by R. S. Moore, Tube Department, RCA; Election of Officers; May 11, 1949.

### WINNIPEG

Election of Officers; May 4, 1949.

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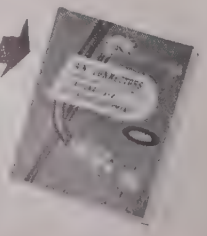

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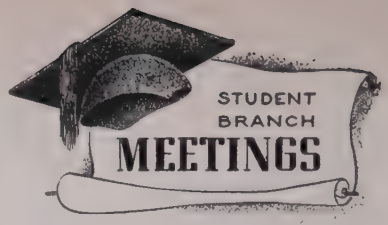


ALABAMA POLYTECHNIC INSTITUTE—IRE BRANCH

Business Meeting; March 28, 1949.
Election of Officers; April 11, 1949.
Business Meeting; April 25, 1949.
Business Meeting; May 9, 1949.

UNIVERSITY OF ARKANSAS—IRE BRANCH

"Kansas City Regional Meeting," by R. Wollfolk, Student; Election of Officers; May 10, 1949.

UNIVERSITY OF CALIFORNIA SOCIETY OF ELECTRICAL ENGINEERS—IRE-AIEE BRANCH

After Dinner Speech, by E. S. Lee, AIEE National President; April 7, 1949.
Inspection Field Trip; April 8 to April 14, 1949.
"Electronic Digital Computer," by P. Morton, Faculty of University of California; April 21, 1949.

CARNEGIE INSTITUTE OF TECHNOLOGY—IRE-AIEE BRANCH

Election of Officers; February 21, 1949.
Student Talks; March 7, 1949.
Student Talks; March 14, 1949.
Student Talks; March 18, 1949.
Student Talks; March 25, 1949.

CASE INSTITUTE OF TECHNOLOGY—IRE BRANCH

"Electronic Control in Industry," by C. Mann, Westinghouse Electric Company; May 3, 1949.
"Television—Its Mechanism and Promise," by W. L. Lawrence, Radio Corporation of America; May 17, 1949.
"Radar and Radio in Astronomy," by J. J. Nassau, Faculty of Case Institute; April 12, 1949.

CLARKSON COLLEGE OF TECHNOLOGY—IRE BRANCH

Election of Officers; May 11, 1949.

UNIVERSITY OF COLORADO—IRE BRANCH

"Principles of Servomechanisms," by D. S. Stacey, Faculty of University of Colorado; May 11, 1949.

UNIVERSITY OF DETROIT—IRE BRANCH

"Radio or Television—Which?" by R. J. Jones, Radio Station WJBK; J. Eberle, Radio Station WWJ; J. F. Steadley, Radio Station WLDM; and D. Cook, Radio Station WDTR; April 26, 1949.

FENN COLLEGE—IRE BRANCH

"Proximity Fuzes," by H. E. Morgan, Faculty of Fenn College; Election of Officers; May 6, 1949.

UNIVERSITY OF FLORIDA—IRA-AIEE BRANCH

"Effects of Electric Shock on the Human Body," by W. F. Fagen, Faculty of University of Florida; April 7, 1949.
"Three-Dimensional Representation on Cathode-Ray Tube," by J. L. Youmans, Student; Election of Officers; April 28, 1949.
"Fundamentals of Electrical Protection in Generating Plants," by W. C. Cogburn, Florida Power and Light Company; May 12, 1949.

STATE UNIVERSITY OF IOWA—IRE BRANCH

Student Talks; March 30, 1949.
Student Talks; April 6, 1949.
"Familiarization with Meters," by C. Miller,

*(Continued on page 46A)*

# R. F. COMPONENTS—MICROWAVE—TEST EQUIPMENT

## 1.25 CENTIMETER

**"K" BEND DIRECTIONAL COUPLER** CU104/APS-34, 20 DB .....$49.50 ea.
**"K" BAND FEEDBACK TO PARABOLA HORN,** with pressurized window .....$30.00
**MITRED ELBOW** cover to cover .....$4.00
**TR/ATR SECTION** choke to cover .....$4.00
**FLEXIBLE SECTION I"** choke to choke ..$5.00
**ADAPTER,** rd. cover to sq. cover .....$5.00
**MITRED ELBOW** and S sections choke to cover .....$4.50
**WAVE GUIDE** ½ x ¼ per ft. .....$1.00
**K BAND CIRCULAR FLANGES** .....50¢

## 10 CENTIMETER

**WAVEGUIDE TO ⅞" RIGID COAX "DOORKNOB" ADAPTER, CHOKE FLANGE, SILVER PLATED, BROAD BAND** .....$49.50 EACH
**WAVEGUIDE DIRECTIONAL COUPLER,** 27 db, Navy type CABV-47AAN, with 4 in. slotted section .....$42.50
**SQ FLANGE** to rd choke adapter, 18 in. long OA 1½ in. x 3 in. guide, type "N" output and sampling probe .....$32.00
**"S" BAND CRYSTAL MOUNT,** gold plated, with 2 type "N" connectors .....$12.50
**PICKUP LOOP,** Type "N" Output .....$2.75
**TR BOX** Pick-up Loop .....$1.25
**POWER SPLITTER:** 726 Klystron input, dual "N" output .....$5.00
**MAGNETRON TO WAVEGUIDE** coupler with 721-A duplexer cavity, gold plated .....$27.50
**10 CM WAVEGUIDE SWITCHING UNIT,** switches 1 input to any of 3 outputs, Standard 1½" x 3" guide with square flanges. Complete with 115 vac or dc arranged switching motor. Mfg. Raytheon. CRP 24AAS, New and complete .....$150.00
**10 CM END-FIRE ARRAY POLYRODS** $1.75 ea.
**"S" BAND** Mixer Assembly, with crystal mount, pick up loop, tunable output .....$3.00
**721-A TR CAVITY WITH TUBE,** Complete with tuning plungers .....$12.50
**10 CM. McNALLY CAVITY** Type SG .....$3.50
**WAVEGUIDE SECTION,** MC 445A, rt. angle bend, 5½" ft. OA, 8" slotted section ..$21.00
**10 CM OSC. PICKUP LOOP,** with male Homedell output .....$2.00
**10 CM DIPOLE WITH REFLECTOR** in Lucite ball, with type "N" or Sperry fitting ...$4.50
**10 CM FEEDBACK DIPOLE ANTENNA,** in lucite ball, for use with parabola ⅞" Rigid Coax Input .....$8.00
**PHASE SHIFTER, 10 CM WAVEGUIDE. WE TYPE ES-683816, E PLANE TO H PLANE. MATCHING SLUGS.** .....$95.00
**721A TR** cavities. Heavy silver plated..$2.00 ea.
10 cm. horn and rotating joint assembly, gold plated .....$65.00 ea.
10 cm. right angle bend "E" or "H" plane, less flanges .....$17.50 ea.
**"S" BAND "Y" JUNCTION.** Sq. Flanges $65.00
10 cm. waveguide to ⅞" rigid coax doorknob transition, 21" high with 8" slotted section .....$52.50 ea.
10 cm. flexible section 4 feet long .....$42.50 ea.
**10 CM FLANGES, UG65/U** .....$8.50
**UG65 U 10 CM. FLANGE** .....$8.50
**ADAPTER** 1½ x 3 to 1" x 2". Sq. 10 cm. Flange to Sq. 5 cm. Choke .....$57.50
**KLYSTRON** Mount W/Tunable matching output to type "N" Connector. Socket & tube clamp included .....$12.50

## ⅞" RIGID COAX—⅜" I.C.

**⅞ RIGID COAX ROTARY JOINT.** Pressurized. Sperry #810613. Gold Plated .....$27.50
Dipole assembly. Part of SCR-584 ....$25.00 ea.
Rotary joint. Part of SCR-584 .....$35.00 ea.
**RIGHT ANGLE BEND,** with flexible coax output pickup loop .....$8.00
**SHORT RIGHT ANGLE BEND,** with pressurizing nipple .....$3.00
**RIGID COAX** to flex coax connector .....$3.50
**STUB-SUPPORTED RIGID COAX,** gold plated 5' lengths. Per length .....$5.00
**RT. ANGLES** for above .....$2.50
**RT. ANGLE BEND 15" L. DA** .....$3.50
**FLEXIBLE SECTION,** 15" L. Male to female .....$1.25
**MAGNETRON COUPLING** to ⅞" rigid coax, with TR pickup loop, gold plated .....$7.50
**FLEX COAX SECT.** Approx. 30 ft. .....$16.50

## ⅞" RIGID COAX—¼" I.C.

**⅞ RIGID COAX, Bead Supported** .....$1.20
**SHORT RIGHT ANGLE BEND** .....$2.50
Rotating joint, with deck mounting.....$15.00
**RIGID COAX** slotted section CU-60/AP...$5.00

## MISCELLANEOUS

Type "N" patching cord UG11/U female to UG9/U using RG5/U cable 12" long..$2.25 ea.
AN/TPS-1B flanged nipple and insert assembly, for rotary coupling .....$3.75 ea.
Pulse connector Navy type 49579 .....$1.50 ea.
Transmission line pressure gauge, 2" 15 lbs. .....$1.85 ea.
Pulse cable assembly Western Electric type D163262, 10 feet long .....$4.50 ea.
Holmdell Jack Western Electric BO-12962-1 D. B.
**ZJ-102X** .....$3.75 ea.
Adapter type "N" RG8/U to RG17/U or 18/U cable .....$4.50 ea.
**ADAPTER TYPE "N" TO RG-71/U CONNECTOR** .....$5.50
**F-29 SPR-2 HIGH PASS FILTER P O AN. APR-5AX, TYPE "N" CONNECTORS.** $12.50
Magnetron coupling to ⅝ rigid coax.....$5.00 ea.
Hand pumps for pressurizing transmission line with humidity indicator .....$12.50 ea.

## PULSE NETWORKS

**15A—1-400-50; 15 KV, "A" CKT.** 1 microsec 400 PPS, 50 ohms imp. .....$42.50
**G.E. #6E3-5-2000-50P2T,** 6KV, "E" circuit, 3 sections, 5 microsecond, 2000 PPS, 50 ohms impedance .....$6.50
**G.E. #3E** (3-.84-810; 8-2-.24-405) 50P4T; 3KV, "E" CKT Dual Unit .....$6.50

## TEST EQUIPMENT

**TS-117 GP** 10 CM Wavemeter Test Set. Mfg. "Sperry." 2400-3400 MC. Micrometer Adj. Coaxial Cavity. Freq. Meas. by Absorption or Transmission Method. Mounts Crystal Current Meter & Calib. Chart .....$145.00
**VSWR Amplifier TS-12/AP, Unit 1, 3 Stages of Amplif. and Diode Rectifier W/Direct VSWS, Reading on Meter. 115 Volts 60 cyc. AC Operation W/Inst. BK and CCT Diag. New** .....$235.00
**Slotted Line Probe and Matched Termination Including Accessories TS-12 AP Unit 2 Incl. UG81 U, CG92 U, CG917U, CG89 U, UG79 U, CG87 U, MX158 U, CG-88 U, CG90/U, UG80/U Plus Tools. New** .....$135.00
**Complete TS-12 AP Units 1 and 2** .....$350.00
**10 CM. Echo Box CABV 14ABA-1 of OBU-3. 2890 MC. to 3170 MCS. Direct Reading Micrometer Head. Ring Prediction Scale Plus 9 to Minus 9. Type "N" Input. Resonance Indicator Meter. New and Comp. W/Access. Box and 10 CM. Directional Coupler** .....$350.00
**3 CM. Receiver. SO-3. Complete with W.G. Mixer Assy. (723 A/B) Reg. Fil. Power Supply. 6 Stages IF (6AC7)** .....$99.50
10 cm. horn assembly consisting of two 5" dishes with dipoles feeding single type "N" output. Includes UG28 U type "N" "T" junction and type "N" pickup probe. Mfg. Bernard Rtes. RGH/U cable. New .....$15.50 ea.
10 cm. cavity type wavemeters 6" deep 6¾" in diameter. Coaxial output. Silver plated .....$64.50 ea.
10 cm echo box. Part of SF-1 Radar with 115 volt DC tuning motor. Sub Sig 1118A $47.50 ea.
**TS33AP WAVEMETER, MICROMETER ADJ. TYPE "N" FITTINGS** .....$125.00
"X" Band test set TS45A, APM-3 using 723 AB oscillator. Input 115 volts single phase 60 to 800 cycles. 0 to 35 DB-attenuator in used, fair condition .....$110.00 ea.
**TS-268/U CRYSTAL TEST SET** for checking 1N21, 1N21A, 1N21B, 1N23, 1N23A, 1N23B crystals. New .....$35.00
**THERMISTOR BRIDGE:** Power meter I-203-A. 10cm. mfg. W.E. Complete with meter, interpolation chart, portable carrying case. $72.50
**W.E. I 138.** Signal generator. 2700 to 2900 Mc. range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input, reg. Pwr. supply. With circuit diagram.....$50.00
3 cm. Wavemeter: 9200 to 11,000 mc. transmission type with square flanges .....$15.00
3 cm. stabilizer cavity, transmission type $20.00
3 cm. Wavemeter. Micrometer head mounted on X-Band guide. Freq. range approx. 7900 to 10.000 Mc. .....$75.00
**TS-238 GP.** 10 cm. Echo box with reasonance indicator and micrometer adjust cavity. 2700 to 2900 Mcs calibrated as shown .....$85.00
Bell Labs. Dual Mount mixer-beacon assemblies. 2 complete mixer-beacon mounts on gold-plated waveguide section .....$50.00
"X" band klystron mount, shielded with rough attenuator output .....$65.00
**TS-108A/P DUMMY LOAD** .....$65.00
**3 CM. HORN AT-48/UP** model 710. Type "N" input. Hvy. silver plated .....$6.50

## 3 CENTIMETER
### (STD. 1" x ½" GUIDE, UNLESS OTHERWISE SPECIFIED)

3 cm. 180° bend with pressurizing nipple $4.00 ea.
3 cm. 90° bend, 14" long 90° twist with pressurizing nipple .....$4.00 ea.
3 cm. "S" curve 18" long .....$5.50 ea.
3 cm. "S" curve 6" long .....$3.50 ea.
3 cm. right angle bends. "E" plane 18" long cover to cover .....$6.50 ea.
3 cm. Cutler feed dipole, 11" from parabola mount to feed back .....$8.50 ea.
3 cm. directional coupler. One way waveguide output .....$15.00 ea.
**TR ATR** section for mounting 1B24 with 721A ATR cavity. Iris coupling flange. Choke to choke .....$12.50 ea.
**APS-31** mixer section for mounting two 2K25's Beacon reference cavity 1B24 TR tube. New and complete with attenuating slugs.....$42.50 ea.
**TRANSITION:** 1 x ½ to 1¼ x ⅝, 14 in. L $8.00
**"X" BAND PREAMPLIFIER,** consisting of 2-723 A/B local oscillator-beacon feeding waveguide and TR/ATR Duplexer sect. incl. 60 mc IF amp .....$67.50
Random Lengths waveguide, 6" to 18" Lg. $1.10 Ft.
**WAVEGUIDE RUN,** 1¼" x ½" guide, consisting of 4 ft. section with Rt. angle bend on one end 2" 45 deg. bend other end .....$8.00
**WAVEGUIDE RUN,** 1¼" x ¼" guide, consisting of 4 ft. long .....$10.00
**"X" BAND PRESSURIZING** gauge section w/15-lbs gauge & Pressurizing Nipple...$18.50
**45 DEG. TWIST** 6" Long .....$10.00
**12" SECTION** 45 deg twist 90 deg. band $6.00
**11" STRAIGHT WAVEGUIDE** section choke to cover. Special heavy construction, silver plated .....$4.50
**15 DEG. BEND** 10" choke to cover.....$4.50
**5 FT. SECTIONS** choke to cover. Silver Plated .....$14.50
**18" FLEXIBLE SECTION** .....$17.50
**"E" and "H" PLANE BENDS** .....$12.50
**BULKHEAD FEED THRU** .....$15.00

## 5 CM.

**2" x 1" RT. ANGLE BEND** choke to cover silver plated .....$38.50
**WAVEGUIDE MIXER CV-12A/APR-6**.....$55.00
**RAPID W.G. FASTENING CLAMPS** .....$5.00

## PULSE EQUIPMENT

**MIT. MOD. 3 HARD TUBE PULSER:** Output Pulse Power: 144 KW (12 KV at 12 amp). Duty Ratio: .001 max Pulse duration: 5, 1.0, 2.0 microsec. Input voltage: 115 v. 400 to 2400 cps. Uses 1-715-B, 1-829-B, 3-'72's. 1-'75. New .....$110.00
**APQ-13 PULSE MODULATOR.** Pulse Width .5 to 1.1 Micro Sec. Rep. rate 624 to 1348 Pps. Pk. pwr. out 35 KW. Energy 0.018 Joules $49.00
**TPS-3 PULSE MODULATOR.** Pk. power 50 amp. 24 KV (1200 KW pk); pulse rate 200 PPS, 1.5 microsec; pulse line impedance 50 ohms, Circuit—series charging version of DC Resonance type. Uses two 705-A's as rectifiers. 115 v. 400 cycle input. New with all tubes $49.50
**APS-10 MODULATOR DECK.** Complete, less tubes .....$75.00
**APS-10** Low voltage power supply, less tubes .....$18.50
725A magnetron pulse transformers.....$18.50 ea.
Megawatt magnetron Pulse XFMR .....$42.50

## MICROWAVE ANTENNAS

**SO-3 RADAR 3 CM. Surface search antenna. Complete with 24VDC drive motor, Selsyn Gear Mechanisms, "X" Band Slotted "Peel" Reflector. Less Plumbing. $135.00. As Shown**
**APS-15** Antennas. New $99.50
**AN MPG-1** Antenna. Rotary feed type high speed scanner antenna assembly, including horn parabolic reflector. Less internal mechanisms. 10 deg. sector scan. Approx. 12'L x 4'W x 3'H. Unused (Gov't Cost—$4500.00) .....$250.00
**APS-4** 3 cm. antenna. Complete. 14½ dish. Cutler feed dipole directional coupler, all standard 1" x ½" waveguide. Drive motor and gear mechanisms for horizontal and vertical scan. New, complete .....$65.00

## R. F. EQUIPMENT

**LHTR. LIGHTHOUSE ASSEMBLY.** Part of RT39/APG-5 & APG-15. Receiver and Transmitter Lighthouse Cavities with Assoc. TR Cavity and Type N CPLG to RCVR. Uses 2C40, 2C43, 1B27, Tunable APX 2400-2700 MCS. Silver plated .....$49.50
Receiver transmitter RT-39A APG-5 10cm. gun laying RF package using 2C40 and 2C43, new. .....$150.00 ea.
**APS-2 10 CM RF HEAD** complete with hard tube (715B) Pulser, 714 Magnetron 417A Mixer, all ⅞" rigid coax. Incl. Rcvr. Front End .....$210.00
Beacon Lighthouse cavity 10 cm with miniature 28 volt DC & FM motor. Mfg. Bernard Rice .....$47.50 ea.
**T-128/APN-19** 10 cm. radar Beacon transmitter package, used, less tubes .....$59.50 ea.
**SO-3** "X" band 3 cm. RF package, new, complete, including receiver unit, as illustrated on Page 337, Volume 23, RAD LAB Series .....$375.00 ea.
Pre-amplifier cavities type "M" 7410590GI to use 446A lighthouse tube. Completely tunable, heavy silver plated construction .....$37.50 ea.
**RT-32APS-6A RF HEAD.** Compl. with 725A Magnetron, Magnet, Pulse XFMR, TR-ATR, 723 A/B Local OSC. and Beacon Mount. Pre-Amplifier. Used but exc. cond. .....$97.50
**AN/APS-15A** "X" Band compl. RF head and modulator, incl. 725A magnetron and magnet, two 723A/B klystrons (local osc. & beacon), 1B24 TR, rcvr-ampl. duplexer, HV supply, blower, pulse xtmr. Peak Pwr Out: 45 KW apx. Input: 115, 400 cy. Modulator pulse duration .5 to 2 micro-sec. apx. 13 KV Pk Pulse. Compl. with all tubes incl. 715-B, 829B, RKR 73, two 72's. Compl. pkg. new.....$210.00

## MAGNETRONS

| Tube | Frq. Range | Pk. Pwr. Out. | Price |
|---|---|---|---|
| 2J31 | 2820-2860 mc. | 265 KW. | $25.00 |
| 2J21-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 2J22 | 3267-3333 mc. | 265 KW. | $25.00 |
| 2J26 | 2992-3019 mc. | 275 KW. | $25.00 |
| 2J27 | 2965-2992 mc. | 275 KW. | $25.00 |
| 2J32 | 2780-2820 mc. | 285 KW. | $25.00 |
| 2J37 | | | $45.00 |
| 2J38 Pkg. | 3249-3263 mc. | 5 KW. | $35.00 |
| 2J39 Pkg. | 3267-3333 mc. | 87 KW. | $35.00 |
| 2J40 | 9305-9325 mc. | 10 KW. | $65.00 |
| 2J49 | 9000-9160 mc. | 58 KW. | $85.00 |
| 2J34 | | | $55.00 |
| 2J61 | 3000-3100 mc. | 35 KW. | $65.00 |
| 2J62 | 2914-3010 mc. | 35 KW. | $65.00 |
| 3J31 | 24,000 mc. | 50 KW. | $55.00 |
| 5J30 | | | $39.50 |
| 714AY | | | $25.00 |
| 718DY | | | $25.00 |
| 720RY | 2800 mc. | 1000 KW. | $50.00 |
| 720CY | | | $50.00 |
| 725-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 730-A | 9345-9405 mc. | 50 KW. | $25.00 |
| 728 AY, BY, CY, DY, EY, FY, GY | | | $50.00 |
| 700 A, B, C, D. | | | $50.00 |
| 706 AY, BY, DY, EY, FY, GY | | | $50.00 |
| Klystrons, 723A/B $12.50; 707B $7/Cavity | | | $20.00 |
| 417A $25.00 | | 2K41 | $65.00 |

## MAGNETRON MAGNETS

| Gauss | Pole Diam. | Spacing | Price |
|---|---|---|---|
| 4850 | ¾ in. | ⅝ in. | $12.50 |
| 5200 | 21/32 in. | ¾ in. | $17.50 |
| 1300 | 1⅝ in. | 1-5/16 in. | $12.50 |
| 1860 | 1⅝ in. | 1½ in. | $14.50 |

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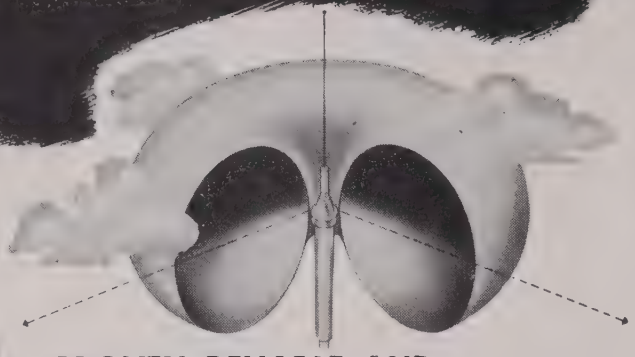

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KEYPORT CP NEW JERSEY


# STUDENT BRANCH MEETINGS

*(Continued from page 44A)*

Weston Meter Corporation; April 12, 1949.

Student Talks; April 20, 1949.

"Development of the Transistor," by R. W. Ryder, Bell Laboratories; April 25, 1949.

Student Talks; May 4, 1949.

KANSAS STATE COLLEGE—IRE BRANCH

Motion Picture on Synchro Systems, by U. S. Navy; May 5, 1949. Election of Officers; May 12, 1949.

LAFAYETTE COLLEGE—IRE-AIEE BRANCH

"The Amplidyne in the Field of Industrial Control," by L. Conover, Faculty of Lafayette College; April 19, 1949.

Election of Officers; April 21, 1949.

"Registration of the Engineer," by C. T. Schoch, President of Pennsylvania Professional Engineer's Association; May 4, 1949.

Student Branch Picnic; May 13, 1949.

LEHIGH UNIVERSITY—IRE BRANCH

"Pulse Modulation," by F. Achaud, Student; "Electronic Differentiation and Integration," by T. G. Schwarz, Student; April 27, 1949.

"Teleran," by D. Houston, Student; Election of Officers; May 19, 1949.

UNIVERSITY OF LOUISVILLE—IRE BRANCH

"Engineering in Broadcasting," by O. W. Towner, Radio Station WHAS; April 28, 1949.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY—IRE-AIEE BRANCH

"Dynamic Noise Suppressor," by H. H. Scott, Herman Hosmer Scott, Inc.; Nomination of Officers; April 20, 1949.

"Evolution and Modern Application of Electric Light Sources," by L. S. Cooke, General Electric Company; April 25, 1949.

UNIVERSITY OF MICHIGAN—IRE-AIEE BRANCH

"Stratovision," by G. B. Saviers, Westinghouse Electric Corporation; April 20, 1949.

"Aircraft Electronic Control Systems," by D. Courter, Lear Inc.; May 11, 1949.

MICHIGAN STATE COLLEGE—IRE-AIEE BRANCH

"The Application of Network Theorems to Vacuum-Tube Circuits," by V. J. Spagnuolo, Student; and "Pulse Modulation Techniques," by N. H. Kramer, Graduate Student; April 14, 1949.

"The Job of a Central Station Engineer," by A. A. Johnson, Westinghouse Electric Corporation; and Film, "Atomic Hydrogen Welding"; April 20, 1949.

"Protective Devices," by E. D. Harder, Bussmann Manufacturing Company; May 18, 1949.

UNIVERSITY OF MISSOURI—IRE-AIEE BRANCH

Film, "Approved by the Underwriters," issued by Underwriters' Laboratories; Election of Officers; April 27, 1949.

UNIVERSITY OF NEBRASKA—IRE-AIEE BRANCH

"Noncyclic Lamp Flicer," by M. Kroeger, Student; Election of Officers; April 20, 1949.

"Electronic Computers," by F. Pelton, Graduate Student; May 11, 1949.

*(Continued on page 47A)*

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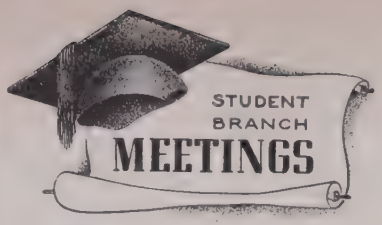



*(Continued from page 46A)*

UNIVERSITY OF NEW MEXICO—IRE BRANCH

"Reflected Power Communication," by Mr. Cassidy, Sandia Base Laboratory; January 12, 1949.

Talk on Papers Given at AIEE Convention, by K. Cooper and G. Lagomarsini, Students; Elections of Officers; May 4, 1949.

COLLEGE OF THE CITY OF NEW YORK—IRE BRANCH

"Job Opportunities in Television and Electronics," by G. Grahm, Director of Television Training NBC; April 26, 1949.

Election of Officers; May 17, 1949.

NEW YORK UNIVERSITY—IRE BRANCH

"The Reeves Analogue Computer," by M. Gerger, Student; April 30, 1949.

"The Electro-Cardiography," by S. Reiner, Research Assistant, New York University; Election of Officers; May 11, 1949.

NORTH CAROLINA STATE COLLEGE—IRE BRANCH

"Radio Broadcasting Problems," by V. Duncan, Radio Station WRAL; Election of Officers; April 6, 1949.

"Varistors," by Mr. Stansel, Bell Telephone Laboratories; Election of Committee Chairmen; April 20, 1949.

"The Development of Low-Frequency Loran," by Dr. Carson, Faculty of North Carolina State College; May 4, 1949.

OREGON STATE COLLEGE—IRE BRANCH

"Carrier Current," by J. V. McGaughy, General Electric Company; April 27, 1949.

"Marine Radar," by Mr. Scott, Westinghouse Electric Corporation; May 3, 1949.

"Extra-High Voltage Development and Trends," by P. L. Bellaschi, Consulting Engineer; May 18, 1949.

UNIVERSITY OF PITTSBURGH—IRE BRANCH

"My Experiences in Radio," by J. Murray, Radio Station KQV; April 14, 1949.

PRATT INSTITUTE—IRE BRANCH

Election of Officers; May 5, 1949.
Business Meeting; May 17, 1949.

PURDUE UNIVERSITY—IRE BRANCH

"The Enginering Considerations of Transistors," by J. A. Morton, Bell Telephone Laboratories, April 29, 1949.

RUTGERS UNIVERSITY—IRE-AIEE BRANCH

Nomination of Officers, May 3, 1949.
Election of Officers; May 9, 1949.

SAN DIEGO STATE COLLEGE—IRE BRANCH

"Citizens' Radio Band—460–470 Mc," by D. Swanson and B. Royce, Students; Business Meeting; April 25, 1949.

SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY—IRE BRANCH

"U. S. Army and Air Force Communication Systems," by H. Dutton, Rapid City Army Air Force Base; Election of Officers; April 20, 1949.

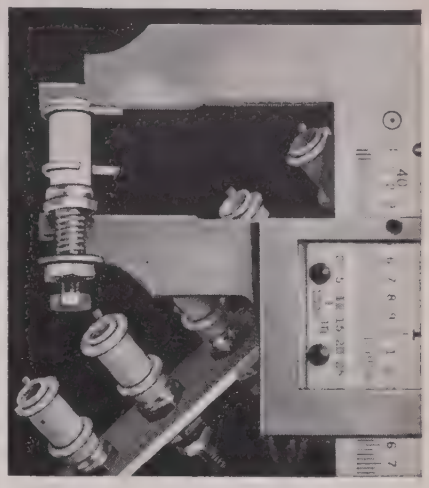
"Single Sideband Radio Telephony," by D. C. Bakeman, Student; May 4, 1949.

SOUTHERN METHODIST UNIVERSITY—IRE-AIEE BRANCH

"Sales Engineering," by Mr. Gray, General Electric Company; Election of Officers; April 29, 1949.

*(Continued on page 48A)*


EXTRA-SMALL . . .
MOISTURE-RESISTANT



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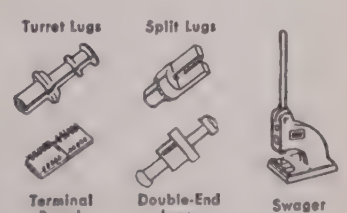


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E. F. JOHNSON CO., WASECA, MINN.


## Student Branch Meetings

*(Continued from page 47A)*

STANFORD UNIVERSITY—IRE-AIEE BRANCH

"UHF Techniques Applied to Tetrode Transmitting Tubes," by J. McCullough, Eitel-McCullough, Inc.; April 13, 1949.

Student Paper Competition for AIEE, talks by E. Cordell, University of California; B. G. Ryland, Stanford University; and J. Ylarraz, Santa Clara University; May 10, 1949.

SYRACUSE UNIVERSITY—IRE-AIEE

"The Engineer," by E. Lee, President of AIEE; May 4, 1949.

UNIVERSITY OF TENNESSEE—IRE BRANCH

"Job Placement After Graduation," by C. H. Weaver, Faculty of University of Tennessee; April 19, 1949.

Election of Officers; May 18, 1949.

UTAH STATE AGRICULTURAL COLLEGE—IRE BRANCH

"Spectograph," by M. C. Cannon, Faculty of Utah State Agricultural College; May 11, 1949.

UNIVERSITY OF WISCONSIN—IRE BRANCH

"Electronics in Meteorology," by V. E. Suomi, Faculty of University of Wisconsin; Election of Officers; March 9, 1949.

WORCESTER POLYTECHNIC INSTITUTE—IRE-AIEE BRANCH

Student Talks; April 14, 1949.

UNIVERSITY OF WYOMING—IRE BRANCH

Film, "Desert Victory"; Election of Officers; May 10, 1949.

**The following transfers and admissions were approved and will be effective as of July 1, 1949:**

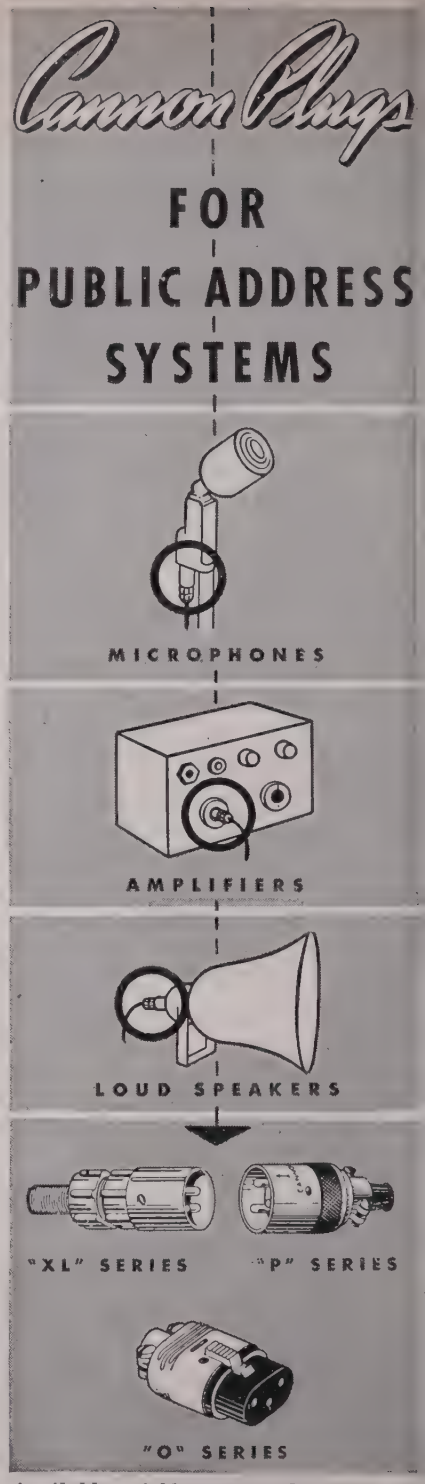
### Transfer to Senior Member

Beasley, W. A., 14 Russel Ave., Fort Monmouth, N. J.
Davis, H., 180 Avenel Blvd., Long Branch, N. J.
Dietsch, C. G., 195 Ames Ave., Leonia, N. J.
Duncan, H. S., 1902 W. Minnehaha Ave., St. Paul 4, Minn.
Fischer, F. P., R.D. 1, Willimantic, Conn.
Grew, L. B., The Southern New England Telephone Company, New Haven 6, Conn.
Morton, J. A., Bell Telephone Laboratories, Inc., Murray Hill, N. J.
Svanascini, A. L., Monroe 4946, Depto. "A," Buenos Aires 31, Argentina
Weichbrod, J., 2525 14 St., N.E., Washington, D. C.
Zimmerman, S. W., 102 Valley Pl., Ithaca, N. Y.

### Admission to Senior Member

Barkson, J. A., 1002 W. Oregon St., Urbana, Ill.
Bescherer, E. A., 66 Old Army Rd., Bernardsville, N. J.
Brady, R. F., 3506 Lee Blvd., Arlington, Va.
Dodd, F. L., 180 Hazelwood Ter., Rochester 9, N. Y.
Liddel, U., Office of Naval Research, Navy Dept., Washington, D. C.
Rice, P. J., Bell Telephone Laboratories, Inc., 463 West St., New York 14, N. Y.

*(Continued on page 49A)*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## MEMBERSHIP

*(Continued from page 48A)*

Rotkin, I., 7728 Emerson Rd., West Lanham Hills, Hyattsville, Md.
Russell, R. M., 14718 Tustin St., Sherman Oaks, Calif.

### Transfer to Member

Ainlay, A., 153 John St., S., Hamilton, Ont., Canada
Beauchemin, A. K., 118 Lexington Ave., Passaic, N. J.
Chapman, R. F., 7130—71 Pl., Glendale, N. Y.
Cohn, G. I., 265 Woodland Rd., Lake Forest, Ill.
Cummings, M. M., 234 Fourth St., Scotia 2, N. Y.
Elbinger, L. P., Electrical Engineering Dept., Illinois Institute of Technology, Chicago 16, Ill.
George, D. E., 8414 12 Ave., Brooklyn 28, N. Y.
Hoff, R. S., 1225 S. Ninth St., Route 2, Gainesville, Fla.
Hubbard, C. L., 205 Humble Bldg., Houston, Tex.
Kreuger, R. E., Box 1663, Los Alamos, N. Mex.
Kulinyi, R. A., 167 Newman Springs Rd., Red Bank, N. J.
Leedom, J. N., 4543 Arcady, Dallas 5, Tex.
McCoy, E. W., Jr., 23 Atkins Ave., Brooklyn 8, N. Y.
McGaughey, P. C., 40 Jefferson Ave., Haddonfield, N. J.
McKinney, C. M., Jr., Rm. 218, Physics Bldg., University of Texas, Austin, Tex.
Pike, W. N., Chesapeake Beach, Md.
Sen, S. M., Svarnasan, Patna, Bankipore, India
Spitalny, M., 121 W. 72 St., New York 23, N. Y.
Stahl, R. J., 67 Northumberland Ave., Redwood City, Calif.
Tandan, R. K., Sunderwala Camp, Dehra Dun, India

### Admission to Member

Beauchamp, E. P., Box N-317, China Lake, Calif.
Bettinson, S. F., "Kinkell," London Rd., Horndean, Portsmouth, Hampshire, England
Burfield, P. C., H.M.S. Ariel (East), Warrington, Lancashire, England
Bushman, F. W., 1227 S. W. 137 St., Seattle 66, Wash.
Croxville, W. B., 43 Stanley St., Clifton, N. J.
Dorsey, S. E., 308-B Independence, China Lake, Calif.
Finkelstein, M. B., 1234 Langham Ave., Camden, N. J.
Guenther, R., 28 Oceanport Ave., Long Branch, N. J.
Harter, J. R. R., 4953 Brandywine St., N.W., Washington 16, D. C.
Hertzberg, J. M., 809 Fairfax Rd., Drexel Hill, Pa.
Hirschl, H. P., 109 New South Head Rd., Edgecliff, Sydney, Australia
Kane, R. W., 519 Brook St., Mamaroneck, N. Y.
Kirby, F. J., Box N-452, China Lake, Calif.
Mack, K. M., 21 Oaklee Village, Baltimore 29, Md.
Melliger, A. W., Box 15, Pleasantville, N. Y.
Michaelson, H. B., 33-51 73 St., Jackson Heights, L. I., N. Y.
Miller, C. F., Johns Hopkins University, 105 Maryland Hall, Baltimore 18, Md.
Minc, A., 3733 80 St., Jackson Heights, L. I., N. Y.
Morris, F. W., Jr., 4308 Palmero Blvd., Los Angeles 43, Calif.
Peterson, C. H., College of Engineering, University of Idaho, Moscow, Idaho
Ross, G. G., General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Ruth, L. C., 12 N. Washington St., Hinsdale, Ill.
Sherman, S. M., 458 S. 27 St., Camden 5, N. J.
Soergel, D. G., 6920 Millbrook Blvd., St. Louis, Mo.
Sonkin, S., Microwave Laboratory, Stanford University, Stanford, Calif.

*(Continued on page 56A)*


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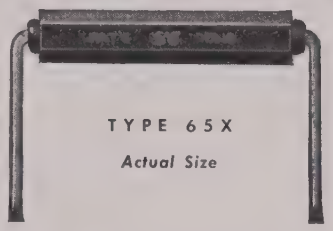
The "All-Weather" Resistors

**Of particular interest to all who need resistors with inherent low noise level and good stability in all climates**

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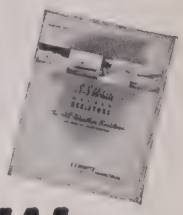
It gives details of both the Standard and High Value resistors, including construction, characteristics, dimensions, etc. Copy with Price List mailed on request.



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**ARNOLD K. WEBER,**
**Personnel Manager, Camden Plant**
**Box 133, RCA Victor Division**
**Radio Corporation of America**
**Camden, New Jersey**

## POSITIONS OPEN

The following positions of interest to I.R.E. members have been reported as open. Apply in writing, addressing reply to company mentioned or to Box No. . . .

**The Institute reserves the right to refuse any announcement without giving a reason for the refusal.**

**PROCEEDINGS of the I.R.E.**
**1 East 79th St., New York 21, N.Y.**

### RESEARCH SCIENTISTS

Experienced research scientists with advanced degrees and experience in physics, serodynamics, electronics, optics, mathematics, chemistry, metallurgy, or meteorology to perform supervisory research and act as permanent consulting group to engineering laboratories. Excellent opportunity for men with right qualifications. Salary $8,000-$14,000 bracket. Write Box 564.

### DEVELOPMENT ENGINEER

Newly formed and rapidly expanding aeronautical instrument company located in New York Metropolitan area is seeking an instrument development engineer who is an electronics and servomechanism specialist to become Chief Engineer. Background must be well balanced in all phases of aeronautical instrument business, including laboratory and shop practice from first hand experience. Interesting salary and bonus. Box 565.

### LABORATORY TECHNICIAN

Excellent opportunity for experienced electronics laboratory technician having experience in aircraft instruments and allied fields. Location Metropolitan New York. Experience and ability in all phases of laboratory testing and shop work desired. Salary commensurate with ability. Box 566.

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Graduate communications engineers, Canadian citizens, interested in audio, radio and video frequency systems engineering. Salaries up to $350.00 per month depending on qualifications. Location, Montreal, Canada. Box 567.

### TELEVISION ENGINEERS

Due to wide expansion in television program of long established radio and television manufacturing company, positions are now available for engineers with 3 or more years television experience. Excellent working conditions in modern, well-equipped laboratory. Company located in northwest portion of New York State. Housing no serious problem. Salaries commensurate with ability. Box 568.

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Wanted for interesting and professionally challenging research and advanced development in the fields of microwaves, radar, gyroscopes, servomechanisms, instrumentation, computers and general electronics. Scientific or engineering degrees or extensive technical experience required. Salary commensurate with experience and ability. Direct inquiries to Mgr., Engineering Personnel, Bell Aircraft Corp., P.O. Box 1, Buffalo 5, N.Y.

*(Continued on page 51A)*

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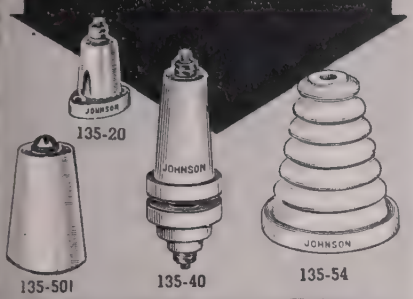
**HIGH FREQUENCIES**

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High breakdown voltage rating of Johnson THRU-PANEL insulator (135-40) is due to long leakage paths. Extrusion of the steatite base passes thru mounting hole preventing internal flashover. Flat mounting surfaces with cushion washers eliminate breakage. Compression construction contributes to high mechanical strength. Available also with banana jack terminal.

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Johnson STAND-OFF insulators (135-20) feature steatite insulation and heavy breakage resistant bases for surface mounting. Johnson 500 series (135-501) is likewise steatite for better high frequency insulation. Threads are tapped directly into the ceramic. They're furnished complete with machine screws, brass and cushion washers.

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# Positions Wanted

*(Continued from page 54A)*

Union. Age 24. 2 years as electronic technician U.S.N. 1½ years design and development of radar receivers and microwave components. Prefer position in vicinity of New York City. Box 289 W.

### ELECTRONIC ENGINEER

B.E.E. 1946. Age 24. 2½ years varied electronic experience including radar development work. Desires electronic development work in New York City area. Box 290 W.

### JUNIOR ENGINEER

B.S.E.E. 1948 University of Illinois. Age 23. Married. Specialized training in television at RCA Institutes. One year experience commercial television receiver servicing. Desires position as research or development engineer. First class radiotelephone license. Box 291 W.

### JUNIOR ENGINEER

Graduated June 1949 from Manhattan College with a B.E.E. degree. 2 years training and experience as Radio-Mechanic-Gunner in the AAF. Age 26, single. Desires employment as electrical or electronic engineer particularly in the television field, anywhere in the States. Box 292 W.

### ENGINEER-MATHEMATICIAN

M.E.E.; B.S.E.E. (communications). B.S.E., mathematics. 1 year research in magnetic amplifiers. Fluent knowledge of German. Age 25, married, no children. Desires research or development in magnetic amplifiers, mathematical design, engineering mathematics instructorship, or technical writing. Available September 1949. New York City or vicinity preferred. Box 293 W.

### TECHNICAL WRITER-COMMUNICATIONS ENGINEER

Technical Writer-Communications Engineer, Military Intelligence Service officer, B.S.R.E. licensed FCC, 1st class phone, amateur radio. Experienced in mobile radio telephony, X-Ray, export trade. Speaks fluently French and Spanish. Desires position in same or allied fields. Box 294 W.

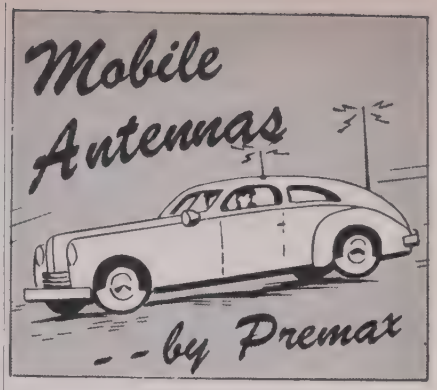
### ELECTRONIC PHYSICIST

B.A., M.A. in Physics. Harvard—M.I.T. Radar School. Radar officer 3 years. Now studying for Ph.D. at Harvard in Engineering Sciences. Age 28, married, 2 children. Desires research in electron physics. Box 295 W.

### ELECTRONIC ENGINEER

Stanford University, B.S.E.E., communications major. Age 24. 1 year broadcasting, 2 years navy electronics experience. 1st class license. Prefer position in broadcasting or electronic development and production. Box 296 W.

*(Continued on page 56A)*

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## *Heavy Duty Telescoping Antennas*

**Where unusually high antennas are required, such as on crash trucks, government service rigs and commercial trucks, Premax can supply telescoping tubular antennas in steel, monel or aluminum, with extended lengths up to over 35 feet. Suitable base mountings permit their use without guying.**

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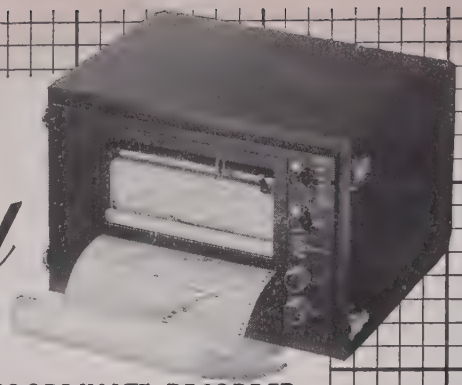

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AIL's Type 373 Recording System plots voltage—or the logarithm of voltage—as a function of time or of the displacement angle of a measured element. The System increases accuracy, delivers inked charts, saves time, eliminates point-by-point plotting.

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160 OLD COUNTRY ROAD
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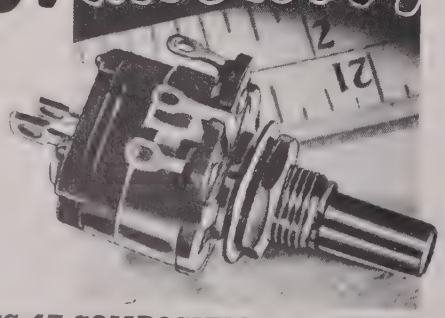

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★ 500 ohms to 5 megohms
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# Positions Wanted

*(Continued from page 55A)*

PROJECT ENGINEER

B.E.E. 1944 Cornell, M.E.E. 1948 Polytechnic Institute of Brooklyn. H.K.N., T.B.P., Sigma Xi at Cornell. Experience in pulse circuits, wide-band I.F. amplifiers, microwaves on microwave P.T.M. relay system, microwave signal generators. F.C.C. 1st class license. Aviation radio-radar officer U. S. Navy. Desires position in television or allied field. Box 255 W.

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Desires selling or distributing products of electronic industries. Graduate of RCA Institutes, education at Bowdoin College, Harvard and M.I.T. in radio engineering. Holder of all FCC commercial radio licenses. 7 years experience in industry. Presently on Staff of a State College. Box 297 W.

*(Continued from page 49A)*

Wolcott, R. G., 11 Seventh Ave., Haddon Heights, N. J.
Zachary, R. A., Jr., 125 Shotwell Pk., Syracuse 6, N. Y.

**The following admissions to Associate were approved and were effective as of June 1, 1949:**

Allen, M. H., 3040 Cruger Ave., New York 67, N. Y.

*(Continued on page 57A)*


PROJECT ENGINEERS

Real opportunities exist for Graduate Engineers with design and development experience in any of the following: Servo-mechanisms, radar, microwave techniques, microwave antenna design, communications equipment, electron optics, pulse transformers, fractional h.p. motors.

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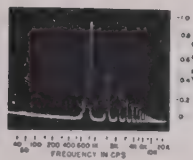
*In only* **1 SECOND!**

**COMPLETE AUDIO WAVEFORM ANALYSIS**

*with the*

**AP-1 PANORAMIC SONIC ANALYZER**

Oscillograph of waveform to be analyzed



Panoramic Sonic Analysis of the same wave

**Provides the very utmost in *speed, simplicity* and *directness* of complex waveform analysis. In only one second the AP-1 *automatically* separates and measures the frequency and amplitude of wave components between 40 and 20,000 cps. Optimum frequency resolution is maintained throughout the entire frequency range. Measures components down to 0.1%.**

- **Direct Reading**
- **Logarithmic Frequency Scale**
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- **Input voltage range 10,000,000:1**

**AP-1 is THE answer for practical investigations of waveforms which vary in a random manner or while operating or design constants are changed. If your problem is measurement of harmonics, high frequency vibration, noise, intermodulation, acoustics or other sonic phenomena, investigate the overall advantages offered by AP-1.**

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Battista, W., 15 W. 47 St., New York 19, N. Y.
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Brace, L. H., 1434 Mott St., Saginaw 21, Mich.
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Campbell, E. A., 323 E. 48 St., New York 17, N. Y.
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Long, E. S., 295 Ft. Washington Ave., New York 32, N. Y.
Mager, J. D., 3906 Maine Ave., Baltimore 7, Md.
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McCallum, A. J., 1528 Telephone Bldg., Kansas City, Mo.
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Nelson, R. A., 2016 Tulane Ave., Beaumont, Tex.
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*(Continued on page 58A)*

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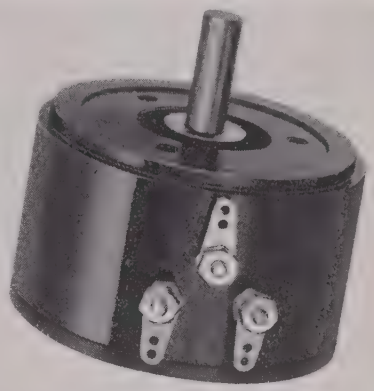
**• VARIABLE**
**• RESISTORS**

**Features common to all T.I.C. Potentiometers**

- Precious Metal Contacts
- Two Rotor Take-Off Brushes
- Adjustable Stop—360° Rotation
- Dustproof Construction
- Low Temperature Coefficient



**Type RV3**

- Resistance Range: 100 to 200,000 ohms
- Electrical Rotation: 315° ± 3°
- Dimensions: 3" Diameter, 1 13/16" Deep
- Power Rating: 9 watts
- Price: Total Resistance ± 5% .....$6.00
  Total Resistance ± 1% .....$8.00

**Type RV3-5**

- Resistance Range: 100 to 50,000 ohms
- Electrical Rotation: 315° ± 3°
- Dimensions: 3" Diameter, 1 5/16" deep
- Power Rating: 5 watts
- Price: Total Resistance ± 5% .....$6.00
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In addition to the above types, T.I.C. is prepared to furnish precision potentiometers designed for highly specialized applications. T.I.C. Engineers will welcome the opportunity to analyze your problem and aid in the development of potentiometers designed specifically to meet your needs.

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# New! Burlington
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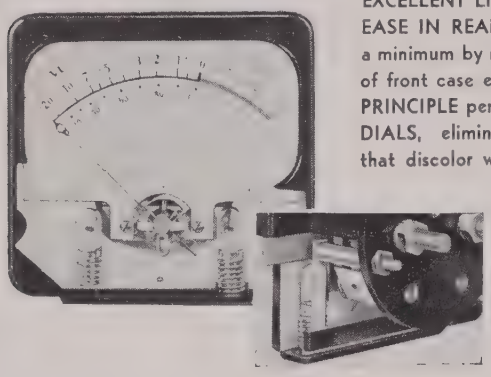

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*Cutaway views showing positions and connections of lamp assembly.*

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**MODEL 84—300-1000 Megacycles**

**OUTPUT VOLTAGE:** Continuously variable from 0.1 to 100,000 microvolts. Output impedance, 50 ohms.

**MODULATION:** Sine Wave: 0-30%, 400, 1000 or 2500 cycles. Pulse: Frequency, 60 to 100,000 cycles. Width, 1 to 50 microseconds. Delay, 0 to 50 microseconds. Sync. output, up to 50 volts, either polarity.

**POWER SUPPLY:** 117 volts, 60 cycles. (Also available for 117 volts, 50 cycles; 220 volts, 60 cycles; 220 volts, 50 cycles.)

**DIMENSIONS:** 12" high x 26" wide x 10" deep, overall.

**WEIGHT:** Approximately 135 pounds, including external line voltage regulator.

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Standard Signal Generators
Pulse Generators
FM Signal Generators
Square Wave Generators
Vacuum Tube Voltmeters
UHF Radio Noise & Field Strength Meters
Capacity Bridges
Megohm Meters
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Television and FM Test Equipment

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Scharf, E., 6236 Chestnut St., Philadelphia, Pa.
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Spilmer, B. H., 864 "A" Ave., Coronado, Calif.
Stoner, M. J., 2402 Military St., Port Huron, Mich.
Stout, T. M., Dept. of Electrical Engineering, University of Washington, Seattle, Wash.
Striebel, J. E., Box 1281, Station A, Bremerton, Wash.
Turner, V. V., Jr., 6722 Japonica St., Houston 17, Tex.
Weaver, W. T., 1345 VanBuren, Beaumont, Tex.
Williamson, J. S., Jr., 2004 Magnolia Ave., Sanford, Fla.
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Wofford, D. R., 3214 Douglas Ave., Memphis 11, Tenn.
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Wright, B. G., 1439 S. 73 St., West Allis 14, Wis.
Yacich, P. J., 1826 Independence St., New Orleans 17, La.
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Zakhaim, M., 40 Arlozovoff, Haifa, Israel
Zelinski, F. P., 5020 N. Hamlin Ave., Chicago 25, Ill.

**The following transfers to the Associate grade were approved to be effective as of March 1, 1949:**

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Basacik, N., 13 S. Loomis St., Chicago, Ill.
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Browning, J. W., Robinsonville, Miss.
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Chomsky, S. R., 233 East 54 St., New York 22, N. Y.
Chong, W. S. P., 5722 Greene St., Philadelphia 44, Pa.
Dame, R. O., 25 Highland Ct., Ukiah, Calif.
Dlouhy, G. J., c/o I.B.M. Corp., 12 & Locust Sts., St. Louis, Mo.
Doland, G. D., 412 W. Price St., Philadelphia 44, Pa.
Drake, A. H., 38 Roslyn Rd., Mineola, L. I., N. Y.
Edelsohn, C. R., 5220 Reading Rd., Cincinnati 29, Ohio
Emmerich, L., 806 Strand, Redondo Beach, Calif.
Fontana, J. A., Box 14, Milldale, Conn.
Gottliebsen, L. H., 6526 17 Ave., Kenosha, Wis.
Greenwood, P. E., Jr., R.F.D. 1, Syracuse 9, N. Y.
Grund, J. B., 114 Seventh St., Emporium, Pa.
Heasty, C. N., Box 5500 I, Albuquerque, N. Mex.
Horowitz, J., 2044 E. 13 St., Brooklyn 29, N. Y.
Huebschen, R. G., 2824 A Magnolia Ave., St. Louis 18, Mo.
Moons, A. G., 1218 Central Ave., Westfield, N. J.
Seid, H. R., 338 Cars St., Jackson, Mich.
Shellhammer, W. I., 300 E. San Salvador, San Jose, Calif.
Sutton, W. R., 2224 Crenshaw Blvd., Los Angeles 16, Calif.
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*(Continued on page 59A)*

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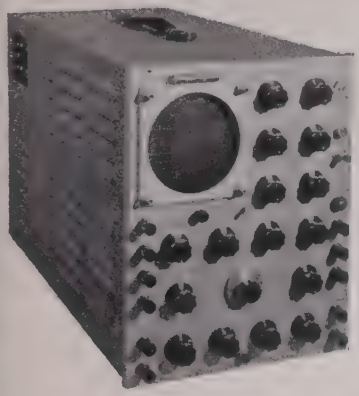
*To serve our customers with products and policies unexcelled in the electronics industry and limited only by the current state of the art.*



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***$845 f.o.b. Portland***

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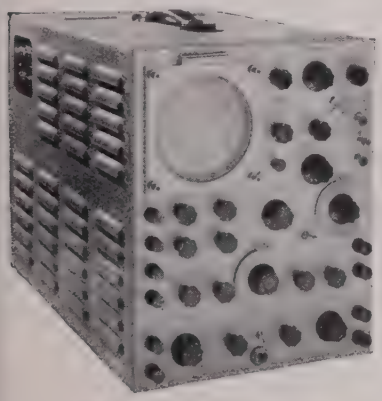
*The Type 511-AD, with its 10 mc. amplifier, 0.25 microsecond video delay line and sweeps as fast as .1 microsec./cm. is excellent for the observation of pulses and high speed transient phenomena. Sweeps as slow as .01 sec./cm. enable the 511-AD to perform superlatively as a conventional oscilloscope.*



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*The Type 512 with a sensitivity of 5 mv./cm. DC and sweeps as slow as .3 sec./cm. solves many problems confronting workers in the fields where comparatively slow phenomena must be observed. Vertical amplifier bandwidth of 2 mc. and sweeps as fast as 3 microsec./cm. make it an excellent general purpose oscilloscope as well.*

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- *Any 20% of normal sweep may be expanded 5 times.*

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TEKTRONIX INC.

Cables, Tektronix
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*(Continued from page 58A)*

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Anderson, J. W., Woodrow Wilson Ct., Box 913, Norman, Okla.
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Browde, A., 819 Archer Ave., Fort Wayne 7, Ind.
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Farris, H. W., Electrical Engineering Department, University of Kentucky, Lexington 29, Ky.
Frater, G. A., 7003 W. Good More Rd., Milwaukee 9, Wis.
Girodias, R. M., 911 Hollywood Ave., New York 61, N. Y.
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Goldwasser, J., c/o A. C. Cossor Ltd., Cossor House, Highbury Grove, London N. 5, England
Gottwald, C. H., 4011 50th, San Diego 5, Calif.
Green, J. W., c/o Geophysical Ser. Inc., 6000 Lemmon Ave., Dallas 9, Tex.
Greenberg, H., 187 Center St., Ellenville, N. Y.
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*(Continued on page 60A)*


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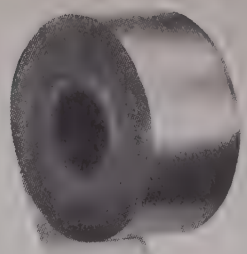

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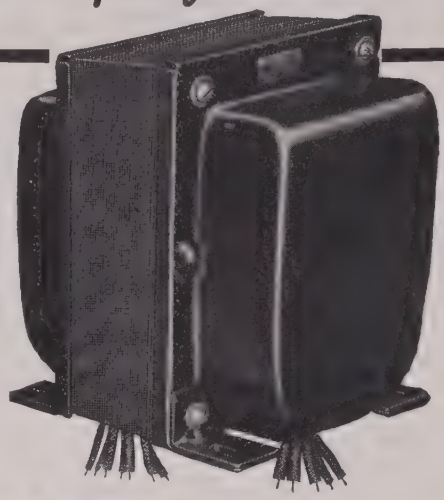

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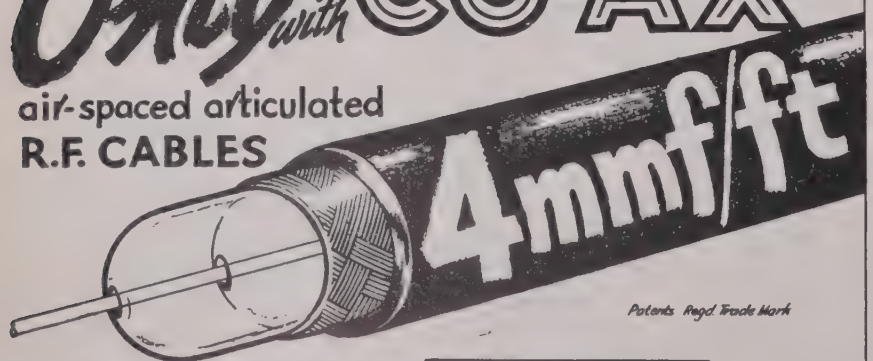


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| PC 1 | 10.2 | 132 | 3.1 | 0.36 |
| C 11 | 6.3 | 173 | 3.2 | 0.36 |
| C 2 | 6.3 | 171 | 2.15 | 0.44 |
| C 22 | 5.5 | 184 | 2.8 | 0.44 |
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Spergel, P., 342 E. 22 St., New York 10, N. Y.
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Stinchcomb, W. B., 2632 S. Seventh St., Milwaukee 7, Wis.
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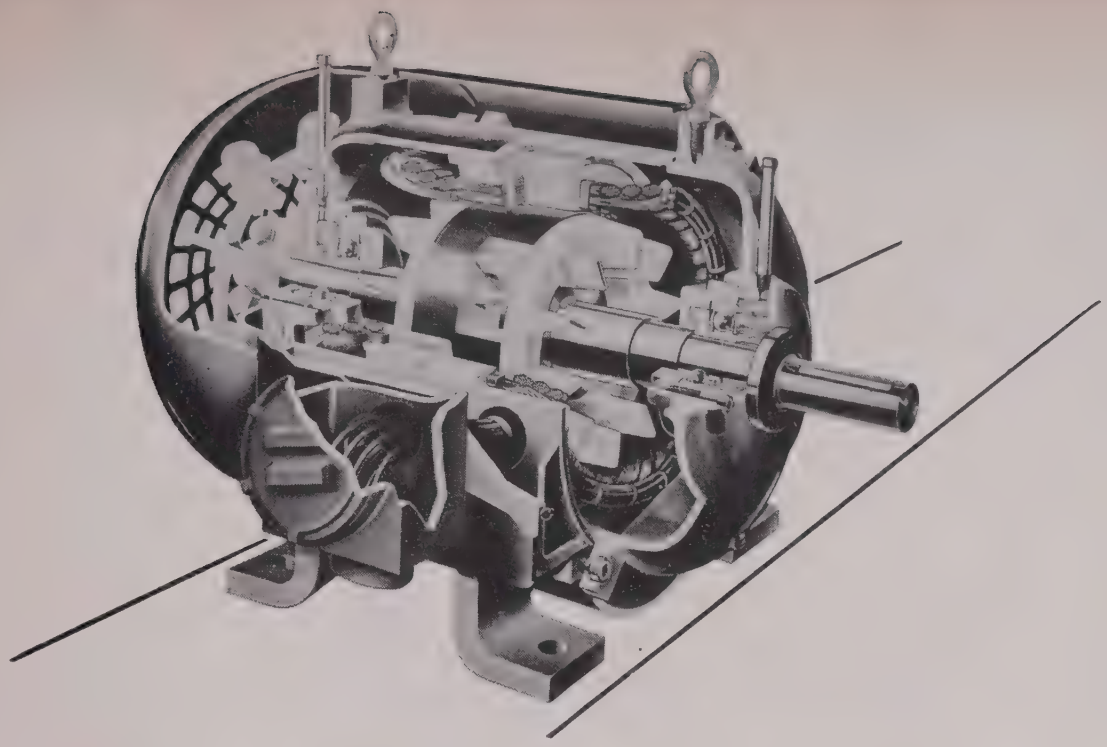

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To provide adequate corrosion resistance for exposed parts, Monel* is used for fan covers and screws, outer stator covers, shaft collars, and lead outlet pipe nipples. Reliance engineers chose Monel for these applications because of its unique combination of physical properties. For in addition to being rust-proof and highly corrosion-resistant, Monel is stronger than structural steel. It is hard, tough, wear-and-abrasion resistant, yet ductile enough for forming and machining without special tools...an ideal metal for use where severe conditions of corrosion, wear, and stress are anticipated.

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## SECTION MEETINGS

ATLANTA

"Discussion of and Tour Through WAGA Television Station," by P. Cram, Chief Engineer, Television Station WAGA; May 20, 1949.

BALTIMORE

"Interference Problems," by E. W. Chapin, Chief Engineer, Federal Communications Commission: "Advantages of FM Transmission of Television Programs in the UHF Band," by W. K. Roberts, Assistant Chief Engineer, Federal Communications Commission; Business Meeting; Nomination of Officers; May 24, 1949.

BEAUMONT-PORT ARTHUR

"Electron Optics and Its Applications," by R. H. Biser, Faculty of Lamar College; May 24, 1949.

BUENOS AIRES

Election of Officers; April 8, 1949.

BUFFALO-NIAGARA

Nomination of Officers; May 12, 1949.

"A Flow Meter for Granular Substances," by J. F. McCullough; "A Magnetic Thickness Gauge," by R. Rowe, Carborundum Company; "Comparisons Between American and British Television," by D. Swaine, Colonial Radio; Election of Officers; May 18, 1949.

BOSTON

"A New Long-Playing Disk Recording System," by P. C. Goldmark, Columbia Broadcasting System, October 26, 1948.

"A New Method for Measuring the Product of Two Voltages Using a Single Vacuum Tube," by D. B. Sinclair, Assistant Chief Engineer, General Radio Company, November 18, 1948.

"The Electronic Theory of the Transistor," by W. Shockley, Bell Telephone Laboratories; December 16, 1948.

"The Physical Concepts in the Statistical Approach to Communication Problems," by R. M. Fano, Massachusetts Institute of Technology; January 20, 1949.

"Traveling-Wave Amplifiers," by H. G. Rudenberg, Raytheon Manufacturing Company; February 17, 1949.

"Radio Telemetering," by C. H. Hoeppner, Raytheon Manufacturing Company; March 24, 1949.

"Psycho-Acoustic Aspects of Speech Compression," by J. C. R. Licklider, Faculty of Harvard University; April 21, 1949.

"Television Station Installation and Operation," by W. H. Hauser and S. V. Stadig, Radio Station WBZ; Election of Officers; May 26, 1949.

"Microwave Spectroscopy," by R. Karplus and E. Fletcher, Faculty of Harvard University; June 17, 1949.

CEDAR RAPIDS

"The Baldwin Electronic Organ," by A. F. Knoblaugh, The Baldwin Piano Company, May 12, 1949.

CINCINNATI

Election of Officers; June 15, 1949.

CLEVELAND

Inspection Tour; "Description of WNBK and WTAM Studios," by E. Leonard, Engineer-in-Charge, National Broadcasting Company Cleveland Facilities; and A. Hammerschmidt, Supervisor, Television Operations; May 26, 1949.

CONNECTICUT VALLEY

Election of Officers; June 4, 1949.

*(Continued on page 39A)*

## SECTION MEETINGS

*(Continued from page 34A)*

DALLAS-FORT WORTH

"Silicones—Electrical Properties and Applications," by Southwest Manager, Dow Corning Corporation; May 17, 1949.

"Pulse Time Modulation," by R. G. Maddox, Federal Telephone and Radio Corporation; June 2, 1949.

DAYTON

"IRE Affairs," by S. L. Bailey, President, The Institute of Radio Engineers; Election of Officers; May 12, 1949.

DETROIT

"FM—FM Telemetering System," by H. B. Schultheis, Research Engineer, Bendix Aviation Corporation; May 20, 1949.

FORT WAYNE

"The Automatic Telephone Exchange," by E. J. Kane, Home Telephone and Telegraph Company, Election of Officers; May 23, 1949.

"Microwaves, Their Development and Use," by M. G. Staton, RCA-Victor Division; "Brain Waves," by C. Mengani, Indiana Technical College; June 13, 1949.

LONDON

"Annual Banquet Meeting," by F. H. R. Pounsett, Stromberg-Carlson Company, Ltd.; February 16, 1949.

"Hysteresis Effects," by J. Young; "Frequency Divider Networks," by D. Aaronson; "Three-Dimensional Cathode-Ray Display," by N. Broten; March 11, 1949.

"Practical Aspects of Modern Directional Broadcast Antenna Arrays," by G. A. Robitaille, Chief Engineer, CFPL; April 29, 1949.

"Practical Discussion of General Antenna Engineering," by J. E. Hayes, Columbia Broadcasting Company; Election of Officers; May 27, 1949.

LOS ANGELES

Television Symposium and panel discussion; May 21, 1949.

MILWAUKEE

Election of Officers; June 9, 1949.

NEW YORK

"The Stratovision System," by C. E. Nobles, Westinghouse Electric Corporation; December 1, 1948.

"The Electron Wave Tube," by A. V. Haeff, Naval Research Laboratory, and J. R. Pierce, Bell Telephone Laboratories; December 16, 1948.

"A Field Test of UHF Television in the Washington Area," by G. H. Brown, RCA Laboratories; January 5, 1949.

"Instantaneous Audience Measurement System (IAMS)," by P. C. Goldmark, J. W. Christense, A. Bark, J. T. Wilner, and A. Goldberg; Columbia Broadcasting System; January 19, 1949.

"A New Microwave Triode," by J. A. Morton, A. E. Bowen, W. W. Mumford, and M. E. Hines, Bell Telephone Laboratories: February 2, 1949.

Motion Picture on "Atomic Physics," by J. R. Dunning, Faculty of Columbia University; February 16, 1949.

"Development of a Large Metal Kinescope for Television," by J. Kelar, H. P. Steier, C. T. Lattimore, and R. D. Faulkner, Radio Corporation of America; February 23, 1949.

"Design Problems in Meeting NAB Tentative Magnetic Recording Standards," by W. E. Stewart, Radio Corporation of America; "Noise Factors in Magnetic Tape Recording," by D. G. C. Hare, Consulting Physicist; March 2, 1949.

"A Facsimile Multiplex System for FM Broadcasting Networks," by W. S. Halstead, President, Communications Research Corporation; April 6, 1949.

*(Continued on page 40A)*

Schematic diagram
No. 791 kilovoltmeter
multiplier

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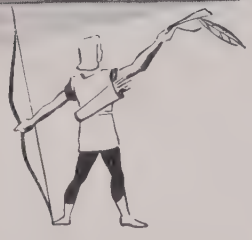

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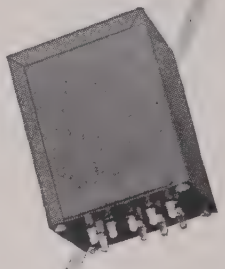

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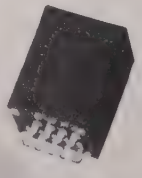

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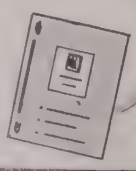

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## Section Meetings

*(Continued from page 39A)*

"Acoustic Lenses for Audio-Frequency Applications," by W. E. Kock, Bell Telephone Laboratories; April 18, 1949.

"Image Quality in Photography and Television," by O. H. Schade, RCA Victor Division; May 4, 1949.

"Some Circuit Aspects of the Transistor," by R. M. Ryder, Bell Telephone Laboratories; Election of Officers; June 1, 1949.

NORTH CAROLINA-VIRGINIA

"Television Station Design," by J. N. Comer, General Electric Company; May 27, 1949.

PITTSBURGH

"Control Problems in Nuclear Power Plants," by M. A. Schultz, Westinghouse Electric Corporation; Election of Officers; June 13, 1949.

PORTLAND

"Changing Patterns that Influence Engineering Decisions," by C. W. Leihy, Executive Vice-President, Electrical Publications, Inc; Dedication of Dearborn Hall, May 28, 1949.

SALT LAKE

"Directional Antennas," by S. Benson, Radio Institute; June 1, 1949.

SAN DIEGO

"Radar System Requirements for Maximum and Minimum Range," by W. S. Ivans, Consolidated Vultee Aircraft Corporation; April 5, 1949.

"Atomic Energy Possibilities," by L. E. Reukema, Faculty of University of California; April 26, 1949.

Television Symposium on "Technical Problems of Studio Production," by R. W. Clark, National Broadcasting Company; "Television Receiver Installation and Service Problems," by L. Borgeson, Radio Corporation of America Service Company, Inc.; Round Table Discussion, led by L. Papernow, Television Broadcasting Company; June 7, 1949.

SEATTLE

"Distributed Amplifier," by R. A. Wilson, Graduate Student, University of Washington; "Base Reflex Increase," by R. Foss, Graduate Student, University of Washington; "RC Coupled Feedback Amplifiers," by L. D. Barter, Graduate Student, University of Washington; May 26, 1949.

"L-1 Carrier Telephone System," by D. Nutting, Pacific Telephone and Telegraph Company; June 10, 1949.

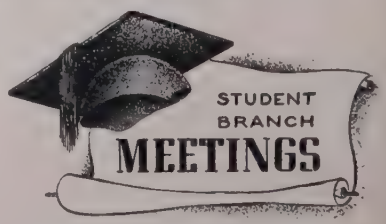
WILLIAMSPORT

"The Use of Stratovision in the UHF Band," by C. E. Noble, Westinghouse Electric Corporation, May 25, 1949.

*SUBSECTIONS*

AMARILLO-LUBBOCK

"Westinghouse 50 Kw AM Transmitter," by Messrs. Massey and McHoney, Sales Engineer and Service Engineer; May 16, 1949.




UNIVERSITY OF CALIFORNIA SOCIETY OF ELECTRICAL ENGINEERS—IRE-AIEE BRANCH

Field Trip; May 10, 1949.
Field Trip; May 19, 1949.

UNIVERSITY OF COLORADO—IRE BRANCH

"The Electret," by W. E. Brittin, Faculty of University of Colorado; Nomination of Officers; May 25, 1949.

*(Continued on page 42A)*

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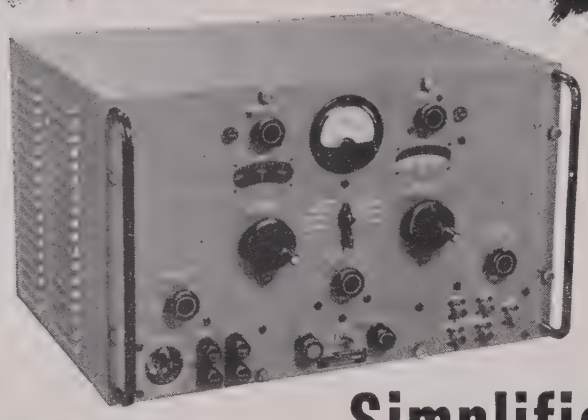

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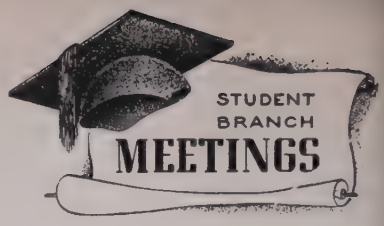


*(Continued from page 40A)*

GEORGIA SCHOOL OF TECHNOLOGY—IRE BRANCH

"Tour of Transmitter Station," by C. F. Daugherty, Radio Station WSB; April 27, 1949.

"Manufacture of Power Transformers," by B. J. Sturman, Jr., Westinghouse Electric Corporation; Election of Officers; May 3, 1949.

Film, "Stepping Along with T-V"; May 19, 1949.

IOWA STATE COLLEGE—IRE-AIEE BRANCH

Election of Officers; May 24, 1949.

STATE UNIVERSITY OF IOWA—IRE BRANCH

Student Talks; May 11, 1949.
Student Talks; May 18, 1949.
Election of Officers; May 25, 1949.

UNIVERSITY OF MINNESOTA—IRE-AIEE BRANCH

"Color Movies on Hawaiian Islands," by R. T. S. Carter, President, RTS Carter Company; May 10, 1949.

NEWARK COLLEGE OF ENGINEERING—IRE BRANCH

"The Graphic Recorder as a Measuring Tool," by L. P. Reitz, Sound Apparatus Company; May 18, 1949.

NEW YORK UNIVERSITY—IRE BRANCH

Business Meeting and Election of Officers; May 24, 1949.

NORTH CAROLINA STATE COLLEGE—IRE BRANCH

"Opportunities for Engineers in the Federal Service," by E. McCrensky, Director of Personnel, Office of Naval Research; May 25, 1949.

OREGON STATE COLLEGE—IRE BRANCH

"High Voltage Power Arc Test," and movie of test, by E. C. Starr, Faculty of Oregon State College; Election of Officers; May 25, 1949.

"Factors Which Affect Engineering Decisions," by C. W. Leihy, Executive Vice-President, Electrical Publications Inc.; and Banquet; May 28, 1949.

PURDUE UNIVERSITY—IRE BRANCH

"Ceramic Dielectric, Ceramic Capacitors, and Printed Circuits," by B. Marks, Centralab Company; Election of Officers; May 31, 1949.

ST. LOUIS UNIVERSITY—IRE BRANCH

Election of Officers; March 24, 1949.

"Telemetering," by P. T. Ramey, Union Electric Company; April 21, 1949.

"Selenium Rectifiers," by F. A. Waelterman, Vickers, Inc.; April 28, 1949.

"Missouri Society of Professional Engineers," by E. S. Rehagen, Westinghouse Electric Corporation; May 19, 1949.

SAN DIEGO STATE COLLEGE—IRE BRANCH

Election of Officers; May 17, 1949.

"Visual Understanding of Video," by R. T. Silberman, Student; May 23, 1949.

SEATTLE UNIVERSITY—IRE BRANCH

Election of Officers; April 21, 1949.

STANFORD UNIVERSITY—IRE-AIEE BRANCH

Election of Officers; "General Electronics Research Picture at Stanford," by F. E. Terman, Faculty of Stanford University; Student Talks; and Open House; May 25, 1949.

UNIVERSITY OF WASHINGTON—IRE-AIEE BRANCH

"Northwest Power Problems," by Mr. Lampson, B.P.A.; December 9, 1948.

Business Meeting; February 9, 1949.

Business Meeting and Nomination of Officers; April 8, 1949.

Business Meeting and Election of Officers; May 2, 1949.

WAYNE UNIVERSITY—IRE-AIEE BRANCH

Election of Officers; May 12, 1949.

"RF Induction Heating," by Mr. Cardwell, Westinghouse Electric Corporation; June 2, 1949.

**The following transfers and admissions were approved and will be effective as of August 1, 1949:**

### Transfer to Senior Member

Baldwin, L. W., Box 118, R.F.D. 1, Oxnard, Calif.
Byers, H. G., 133 Glengarry Ave., Toronto 12, Ont., Canada
Courtney, J. M., 359 N. Datil Dr., Albuquerque, N. Mex.
Davis, A., Jr., 920 East 49, Austin, Tex.
Dennison, B. H., 1314 S. Pollard St., Arlington, Va.
De Shong, J. A., Jr., 1414 N. Austin Bldv., Oak Park, Ill.
Hidy, J. H., 4410 S. Peoria, Box 58, Tulsa, Okla.
Klein, R. M., 2200 Morris Ave., New York 53, N. Y.
Lundahl, T., Columbus, Sherburne, N. Y.
Martin, A. E., 226 West 137 St., New York 30, N. Y.
Masters, R. W., Marlton Pike & Wesley Ave., Erlton, N. J.
McGaughey, J. R., Navy Electronics Laboratory, San Diego 52, Calif.
Perper, L. J., 3255 Ridge Ave., Dayton 5, Ohio
Rochester, N., R.F.D. 2, Wappingers Falls, N. Y.
Rollefson, K. E., 1615 Ridge Ave., Evanston, Ill.
Shepherd, W. G., 2176 Stanford Ave., St. Paul, Minn.
Talmage, F. E., 340 Comly Ave., W. Collingswood, N. J.

### Admission to Senior Member

Altovsky, V. A., 88 rue Lecourbe, Paris 15, France
Bartlett, S. C., 74 Etville Ave., Yonkers 2, N. Y.
Bernreuter, H. A., 5208 W. Kinzie St., Chicago 44, Ill.
Bowie, W. G., 302 Houston Ave., Syracuse 10, N. Y.
Dorff, L. A., 92 Hawthorne St., Glen Ridge, N. J.
Fong, L. B. C., National Bureau of Standards, Electronics Division, Washington, D. C.
Given, F. J., Bell Telephone Laboratories, Murray Hill, N. J.
Hoekstra, C. E., 2912 Holton Ave., Fort Wayne 5, Ind.
Hosmer, E. A., 420 Market St., San Francisco 11, Calif.
Kendall, H. C., 143 Edgemont Rd., Rochester 7, N. Y.
Landrey, L. R., 58 Elm St., Lynbrook, L. I., N. Y.
McGraw, J. E., Army Field Forces Board #4, Fort Bliss, Tex.
Merrill, L. L., Clarkson College, Potsdam, N. Y.
Moisson, A. A., 4 Square Charles Laurent, Paris 15, France
Philipps, R. J., 37 Lexington Dr., Livingston, N. J.
Rawlins, R. E., 11180 Emelita St., North Hollywood, Calif.
Raymond, F. H., 37 Avenue des Courlis, Le Vesinet, (Seine & Oise), France

*(Continued on page 44A)*

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*(Continued from page 43A)*

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Victoreen, J. A., 3800 Perkins Ave., Cleveland 14, Ohio

### Transfer to Member

Bedwell, T. H., Physics Department, Florida State University, Tallahassee, Fla.
Bittner, B. J., 3110-42 Pl., Sandia Base Branch, Albuquerque, N. Mex.
Bodle, D. W., Bell Telephone Laboratories, 463 West St., New York 14, N. Y.
Brannen, P. M., 24½ N. Fifth St., Duquesne, Pa.
Florman, L. W., 413 N. Rush St., Itasca, Ill.
Gross, J., Box 973, Nairobi, Kenya Colony, British East Africa
Hancock, N. W., 600-13 St., N. W., Cedar Rapids, Iowa
Hoffman, R. Y., Jr., 1234 Ridgewood Dr., Northbrook, Ill.
Jorgenson, T. O., WEAU Transmitter, R. R. 1, Hy Q, Eau Claire, Wis.
Osbahr, B. F., 206 Eighth Ave., Brooklyn 15, N. Y.
Pfefer, B. L., 428 Woodbine Ave., Syracuse 6, N. Y.
Ratts, B. H., 2506 Terrace Rd., Fort Wayne 3, Ind.
Schull, G. R., 12131 Mayfield Ave., Los Angeles 24, Calif.
Waller, M. J., R.F.D. 1, Foxboro, Ont., Canada
Winkler, E. H., 71 White St., Shrewsbury, Red Bank, N. J.
Young, C. W., 4745 Nogal St., San Diego 2, Calif.
Zupnick, I. N., 768 Linden Blvd., Brooklyn 3, N. Y.

### Admission to Member

Allan, D. K., 925 Louisiana Ave., Baton Rouge, La.
Anderson, C. W., 920 Pine St., St. Louis 1, Mo.
Baker, E. E., Jr., Box 379, APO 182, c/o Postmaster, San Francisco, Calif.
Belprez, G. R., 1322 Chalmers Ave., Detroit 15, Mich.
Bettis, E. S., Box 105, Oak Ridge, Tenn.
Bindner, J. T., 1586 Hedding Ct., San Jose 11, Calif.
Chess, R. B., 1830 South 54 Ave., Chicago 50, Ill.
Collier, J. W., 1903 Ridge Pl., Washington, D. C.
Cooke, H. F., Apt. 17, Maxwell Ct., Mains Ave., Syracuse, N. Y.
Dahl, A. H., 114 Disston Rd., Oak Ridge, Tenn.
Danielsen, A. C., 1429 South 51, Milwaukee 14, Wis.
Das, P. N., 1 Bhaduri Lane, P.O. Serampore, Dist. Hooghly, Bengal, India
Diehl, C. E., Box 1535, Salt Lake City 11, Utah
Frenkel, L. J., Jr., 216 South Yale, Albuquerque, N. Mex.
Hassel, E. W., 2911 Erie St., Racine, Wis.
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*(Continued on page 45A)*


# Spectrum Analysis
## from AF to UHF
***Faster and Simpler with these***
**Panoramic Instruments**

Whether your problem is investigation of noises, vibrations, harmonics, characteristics of AM FM or pulsed signals, oscillations, cross modulation, transmission characteristics of lines and filters, telemetering or any phenomena requiring spectrum analysis, these panoramic instruments will help collect information **faster, easier** and **accurately.** Panoramic instruments automatically visualize spectral content. Indications in the form of vertical pips whose height and horizontal location respectively show signal level and frequency, enable rapid examination of one or more signals at one time.

AP-1

**PANORAMIC SONIC ANALYZER AP-1**
**Complete Audio Waveform Analysis in One Second**

Recognized as THE practical answer for analyzing waves of random or static character, the AP-1 automatically separates and measures complex wave components in only one second.

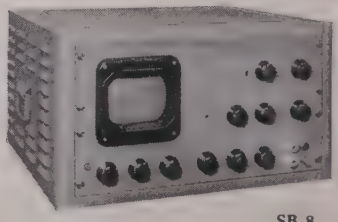
**Frequency Range:** 40-20,000 c.p.s., log scale.
**Input Voltage Range:** 500 μV-500V.
**Voltage Scale:** linear and two decade log, harmonic products suppressed by at least 60 db. **Direct Reading. Simple Operation. Optimum Resolution.**

SB-7

**PANORAMIC ULTRASONIC ANALYZER**
**Entirely New for Ultrasonic Studies**

An invaluable new direct reading instrument, the SB-7 enables overall observation of the ultrasonic spectrum or very highly detailed examination of any selected narrow segment of the spectrum.

**Frequency Range:** 2KC-300 KC, linear scale.
**Scanning Width:** Continuously variable, 200 KC to zero.
**Input Voltage Range:** 1 mV-50V.
**Amplitude Scale:** linear and two decade log.



SB-8

**PANALYZOR—PANADAPTOR**
**For RF Spectrum Analysis**

Long accepted as the simplest and fastest means of observing segments of the RF Spectrum, Panadaptor units operate with superheterodyne receivers, which tune in the segment to be examined. Panalyzors use an external signal generator for this purpose and have a flat amplitude response for determining relative levels of signals.

Both are available in over a dozen standard models and types differing in . . . **Maximum Scanning Widths** ranging from 50KC to 20MC, continuously variable to zero. **Signal Resolution Capabilities** from 250KC down to 100 CPS.

**Write for Complete Technical Data**

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10 SOUTH SECOND AVE. MOUNT VERNON, N. Y.

*(Continued from page 44A)*

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Musicaro, J. S., 1834-71 St., Brooklyn 14, N. Y.
Newhouse, P. D., 2955 N. Lowell Ave., Chicago, Ill.

*(Continued on page 47A)*


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## A new transmission line based upon a new plastic—TEFLON

CP TEF-LINE transmission line, utilizing DuPont Teflon insulators, greatly reduces high frequency power losses. Furthermore, operation of transmission line at frequencies heretofore impossible owing to excessive power loss now becomes easily possible. For TV, FM and other services utilizing increasingly high frequencies, TEF-LINE by CP is a timely and valuable development worthy of investigation by every user of transmission line.

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Check your transmission line requirements with the new CP TEF-LINE BULLETIN which is available on request. If you need help in planning installations, our engineers will be happy to talk over specific problems at your convenience.

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• LO-LOSS SWITCHES • COAXIAL DIPOLE ANTENNAS
• SEAL-O-FLANGE TRANSMISSION LINE

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**"K" BAND DIRECTIONAL COUPLER** CU104/APS-34 20 DB .....$49.50 ea.
**"K" BAND FEEDBACK TO PARABOLA HORN,** with pressurized window .....$30.00
**MITRED ELBOW** cover to cover .....$4.00
**TR/ATR SECTION** choke to cover .....$4.00
**FLEXIBLE SECTION** 1" choke to choke ....$5.00
**ADAPTER,** rd. cover to sq. cover .....$5.00
**MITRED ELBOW** and S sections choke to cover $4.50
**WAVE GUIDE** ½ x ¼ **per ft.** .....$1.00
**K BAND CIRCULAR FLANGES** .....50¢

### 10 CENTIMETER

**WAVEGUIDE** TO ⅞" RIGID COAX "DOORKNOB" ADAPTER. CHOKE FLANGE. SILVER PLATED. BROAD BAND .....$49.50 EACH
**WAVEGUIDE DIRECTIONAL COUPLER.** 27 db. Navy type CABV-47AAN, with 4 in. slotted section .....$42.50
**SQ. FLANGE** to rd choke adapter, 18 in. long OA 1½ in. x 3 in. guide, type "N" output and sampling probe .....$32.00

**10 cm. waveguide** to ⅞" rigid coax doorknob transition, 21" high with 8" slotted section $52.50 ea.
**10 cm. flexible section** 4 feet long ....$42.50 ea.
**10 CM. FLANGES,** UG65/U .....$8.50
**UG65/U 10 CM. FLANGE** .....$8.50
**ADAPTER** 1½ x 3 TO 1" x 2". SQ. 10 CM FLANGE TO SQ 5 CM CHOKE .....$57.50
**KLYSTRON MOUNT** W/TUNABLE MATCHING OUTPUT TO TYPE "N" CONNECTOR SOCKET & TUBE CLAMP INCLUDED ..$12.50
**"S" BAND CRYSTAL MOUNT,** gold plated, with 2 type "N" connectors .....$12.50
**PICKUP LOOP,** Type "N" Output .....$2.75
**TR BOX** Pick-up Loop .....$1.25
**POWER SPLITTER:** 726 Klystron input, dual "N" output .....$5.00
**MAGNETRON TO WAVEGUIDE** coupler with 721-A duplexer cavity, gold plated ....$27.50
**10 CM WAVEGUIDE SWITCHING UNIT,** switches 1 input to any of 3 outputs. Standard 1½" x 3" guide with square flanges. Complete with 115 vac or dc arranged switching motor. Mfg. Raytheon. CRP 24AAS. New and complete .....$150.00
**10 CM END-FIRE ARRAY POLYRODS** ..$1.75 ea.
**"S" BAND** Mixer Assembly, with crystal mount, pick-up loop, tunable output .....$3.00
**721-A TR CAVITY WITH TUBE.** Complete with tuning plungers .....$12.50
**10 CM McNALLY CAVITY** Type SG .....$3.50
**WAVEGUIDE SECTION,** MC 445A, rt. angle bend. 5½" ft. OA. 8" slotted section ..$21.00
**10 CM OSC. PICKUP LOOP,** with male Homedell output .....$2.00
**10 CM DIPOLE WITH REFLECTOR** in lucite ball, with type "N" or Sperry fitting ..$4.50
**10 CM FEEDBACK DIPOLE ANTENNA.** in lucite ball, for use with parabola ⅞" Rigid Coax Input .....$8.00
**PHASE SHIFTER.** 10 CM WAVEGUIDE. WE TYPE ES-683816. E PLANE TO H PLANE MATCHING SLUGS .....$95.00
**721A TR cavities.** Heavy silver plated ..$2.00 ea.
**10 cm. horn** and rotating joint assembly, gold plated .....$65.00 ea.
**10 cm. right angle bend** "E" or "H" plane, less flanges .....$17.50 ea.

⅞" RIGID COAX—¼" I.C.

⅞" **RIGID COAX.** Bead Supported .....$1.20
**SHORT RIGHT ANGLE BEND** .....$2.50
**Rotating joint,** with deck mounting .....$15.00
**RIGID COAX,** slotted section CU-60/AP .$5.00
**"S" BAND "Y" JUNCTION.** SQ. FLANGES $65.00

⅞" RIGID COAX—⅜" I.C.

⅞" **RIGID COAX ROTARY JOINT.** PRESSURIZED. SPERRY #810613. GOLD PLATED $27.50
**Dipole assembly.** Part of SCR 584 ....$25.00 ea.
**Rotary joint.** Part of SCR-584 .....$35.00 ea.
**RIGHT ANGLE BEND,** with flexible coax output pick-up loop .....$8.00
**SHORT RIGHT ANGLE** bend, with pressurizing nipple .....$3.00
**RIGID COAX** to flex coax connector .....$3.50
**STUB-SUPPORTED RIGID COAX,** gold plated 5' lengths. Per length .....$5.00
**RT. ANGLES** for above .....$2.50
**RT. ANGLE BEND** 15" L. OA .....$3.50
**FLEXIBLE SECTION.** 15" L. Male to female $4.25
**MAGNETRON COUPLING** to ⅞" rigid coax, with TR pickup loop, gold plated .....$7.50
**FLEX COAX SECT.** Approx. 30 ft. .....$16.50

### MISCELLANEOUS

**Type "N" patching cord** UG11/U female to UG9/U using RG5/U cable 12" long ..$2.25 ea.
**AN/TPS-1B flanged nipple and insert assembly** for rotary coupling .....$3.75 ea.
**Pulse connector** Navy type 49579 ....$1.50 ea.
**Transmission line pressure gauge.** 2" 15 lbs. $1.85 ea.
**Pulse cable assembly** Western Electric type D163262. 10 feet long .....$4.50 ea.
**Holmdell Jack** Western Electric #BO-12962-1 D.B. #J-102X .....$3.75 ea.
**Adaptor type "N"** RG8/U to RG17/U or 18/U cable .....$4.50 ea.
**ADAPTER TYPE "N" TO RG-17/U CONNECTOR** .....$5.50
**F-29/SPR-2 HIGH PASS FILTER** P/O AN/APR-5AX. TYPE "N" CONNECTORS .....$12.50
**Magnetron coupling** to ⅝ rigid coax ..$5.00 ea.
**Hand pumps** for pressurizing transmission line with humidity indicator .....$12.50 ea.

### MARINE RADAR

**SO-1 AND SO-8 RADAR SETS, Complete, in Used but Excellent Condition. 10 CM Surface Search using 2J26 or 2J27 Magnetron, 707B Mixer. PPI Indicator. Input 115VDC. Used on Merchant Ships throughout the world. FCC Approved. Guaranteed. $1250.00.**

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**TS-268/U crystal test set** for checking IN21, IN21A, IN21B, IN23, IN23A, IN23B crystals. New $35.00
**TS-117GP 10 CM WAVEMETER TEST SET.** Mfg. "Sperry". 2400-3400 MC. Micrometer Adj. Coaxial Cavity. Freq. Meas by absorption or transmission method. Mounts Crystal Current Meter & Calib. Chart .....$145.00
**VSWR AMPLIFIER TS-12/AP.** Unit 1 3 stages of Amplif. and Diode Rectifier w/direct VSWR. reading on meter. 115 volts 60 cyc. AC operation w/Inst. BK and CCT diag. New $235.00
**SLOTTED LINE PROBE** and Matched Termination incld'g Accessories TS-12/AP Unit 2 incl. UG81/U, CG92/U, CG91/U, CG89/U, UG79/U, CG87/U, MX158/U, CG-88/U, CG/90U, UG/80U plus Tools. New .....$135.00
**COMPLETE TS-12/AP UNITS 1 AND 2** ..$350.00
**10 CM ECHO BOX CABV** 14ABA-1 of OBU-3. 2890 MC to 3170 MCS, direct reading micrometer head. Ring prediction scale plus 9% to minus 9%. Type "N" input. Resonance indicator meter. New and Comp. w/access. Box and 10 CM Directional Coupler .....$350.00
**3 CM RECEIVER.** SO-3. Complete with W.G. Mixer Assy (723 A/B) Reg. Fil. Power Supply, 6 Stages IF (6AC7) .....$99.50
**10 cm. horn assembly** consisting of two 5" dishes with dipoles feeding single type "N" output. Includes UG28/U type "N" "T" junction and type "N" pickup probe. Mfg. Bernard Rice, RGH/U cable. New .....$15.50 ea.
**10 cm. cavity type wavemeters** 6" deep 6¼" in diameter. Coax. output. Silver plated $64.50 ea.
**10 cm. echo box.** Part of SF-1 Radar with 115 volt DC tuning motor Sub Sig 1118A **$47.50 ea.**
**TS33AP WAVEMETER.** MICROMETER ADJ. TYPE "N" FITTINGS .....$125.00
**THERMISTOR BRIDGE:** Power meter 1-203-A. 10 cm. mfg. W.E. Complete with meter, interpolation chart, portable carrying case ..$72.50
**W. E. I. 138.** Signal generator. 2700 to 2900 Mc. range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input, reg. Pwr. supply. With circuit diagram .....$50.00
**3 cm. Wavemeter:** 9200 to 11,000 mc. transmission type with square flanges .....$15.00
**3 cm. stabilizer** cavity, transmission type ..$20.00
**3 cm. Wavemeter, Micrometer** head mounted on X-Band guide. Freq. range approx. 7900 to 10,000 Mc .....$75.00
**TS-238 GP.** 10 cm. Echo box with resonance indicator and micrometer adjust cavity, 2700 to 2900 Mcs calibrated as shown .....$85.00
**Bell Labs.** Dual Mount mixer-beacon assemblies. 2 complete mixer-beacon mounts on gold plated waveguide section .....$50.00
**"X" band klystron mount,** shielded with rough attenuator output .....$65.00
TS-108A/P DUMMY LOAD .....$65.00
3 CM. HORN AT-48/UP Model 710. Type "N" Fast. Hvy. Silver Plated .....$6.50

### MICROWAVE ANTENNAS

**SO-3 RADAR 3 CM. SURFACE SEARCH ANTENNA.** Complete with 24 VDC Drive Motor, Selsyn, Gear Mechanisms, "X" Band Slotted "Peel" Reflector. Less Plumbing .....$135.00 As Shown
**APS-15 Antennas.** New ....$99.50
**AN MPG-1 Antenna.** Rotary feed type high speed scanner antenna assembly, including horn parabolic reflector. Less internal mechanisms. 10 deg. sector scan. Approx. 12'L x 4'W x 3'H. Unused. (Gov't Cost—$4500.00) .....$250.00
**APS-4 3 cm. antenna.** Complete. 14½ dish. Cutler feed dipole directional coupler, all standard 1" x ½" waveguide. Drive motor and gear mechanisms for horizontal and vertical scan. New, complete .....$65.00
**AN/TPS3.** Parabolic dish type reflector approx. 10' diam. Extremely lightweight construction. New in 3 carrying cases .....$89.50
**RELAY SYSTEM PARABOLIC REFLECTORS:** approx. range: 2000 to 6000 mc. Dimensions: 4' x 3' rectangle, now .....$35.00
**TDY "JAM" RADAR ROTATING ANTENNA.** 10 cm. 30 deg. beam. 115 v.a.c. drive. New $100.00
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**DBM ANTENNA.** Dual, back-to-back parabolas with dipoles. Freq. coverage 1,000-4,500 mc. No drive mechanism .....$65.00
**AS125/APR** Cone type receiving antenna, 1080 to 3208 megacycles. New .....$4.50
**140-600 MC. CONE** type antenna, complete with 25' sectional steel mast, guys, cables, carrying case, etc. New .....$49.50
**ASD** 3 cm. antenna, used, ex. cond. ....$49.50
**YAGI ANTENNA** AS-46A. APG-4, 5 elements $14.50 ea.

### R. F. EQUIPMENT

**LHTR. LIGHTHOUSE ASSEMBLY.** Part of RT-39/APG-5 & APG-15. Receiver and Transmitter Lighthouse Cavities with assoc. Tr. Cavity and Type N CPLG. To Rcvr. Uses 2C40, 2C43, 1B27. Tuneable APX 2400-2700 MCS. Silver plated .....$49.50
**Receiver transmitter.** Rt-39A/APG-5 10 cm. gun laying RF package using 2C40 and 2C43, new .....$150.00 ea.
**APS-2 10CM RF HEAD COMPLETE WITH HARD TUBE** (715B) Pulser, 714 Magnetron 417A Mixer all ⅞" rigid coax. incl. rcvr. front end .....$210.00
**Beacon lighthouse cavity 10 cm** with miniature 28 volt DC FM motor. Mfg. Bernard Rice .....$47.50 ea.
**T-128/APN-19 10 cm. radar Beacon transmitter package,** used, less tubes .....$59.50 ea.
**SO-3 "X" banc 3 cm RF package,** new complete, including receiver unit as illustrated on Page 337, Volume 23 RAD LAB Series .....$375.00 ea.
**Pro-amplifier cavities** type "M" 7410590GL to use 446A lighthouse tube. Completely tunable. Heavy silver plated construction ..$37.50 ea.
**RT32/APS 6A RF HEAD.** Compl. with 725A Magnetron magnet pulse xfmr. TRA-ATR. 723 A/B local osc. and beacon mount, pre amplifier. Used but exc. cond. .....$97.50
**AN/APS-15A** "X" Band compl. RF head and modulator, incl. 725-A magnetron and magnet, two 723A/B klystrons (local osc. & beacon), 1B24, TR, rcvr-ampl. duplexer, HV supply, blower, pulse xtmr. Peak-Pwr Out: 45 KW apx. Input: 115, 400 cy. Modulator pulse duration .5 to 2 micro-sec. apx. 13 KV Pk Pulse. Compl. with all tubes incl. 715-B, 829B, RKR 73, two 72's. Compl. pkg., new ..$210.00
**APS-15B.** Complete pkg. as above, less modulator .....$150.00
**"S" BAND AN/APS-2.** Complete RF head and modulator, including magnetron and magnet, 417-A mixer, TR, receiver, duplexer, blower, etc., and complete pulser. With tubes, used, fair condition .....$75.00
**10 CM, RF Package.** Consists of: SO Xmtr.-receiver using 2J27 magnetron oscillator, 250 KW peak input. 707-B receiver-mixer ..$150.00

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- Internal pulse generator with controls for width, delay, and rate. Provision for external pulsing
- Controls planned and grouped for ease of operation
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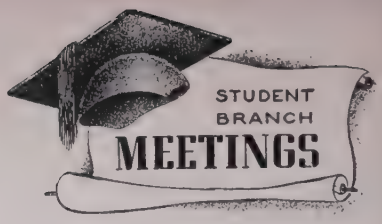



FENN COLLEGE—IRE BRANCH

"Microwave Relay Systems for Television with Demonstration," by O. Henderson, Ohio Bell Telephone Company; June 24, 1949.

ATLANTA

"History and Program for Development and Operation of WGST-FM," by Ben Akerman, Chief Engineer, Radio Station WGST-FM; June 24, 1949.

BALTIMORE

Inspection Tour of Television Station WAAM; June 20, 1949

BEAUMONT-PORT ARTHUR

"The IRE and You," by J. C. Petkovšek, Past Chairman, Beaumont-Port Arthur Section; June 23, 1949.

COLUMBUS

"Theoretical and Experimental Studies of Radio Interference Transients from Precipitation-Static and Corrective Measures," by M. M. Newman, Lightning and Transients Research Institute; April 15, 1949.

"Television Transmitting and Microwave Pickup," by C. Sloan, Chief Engineer, Radio Station WLWC; Tour of Radio Station WLWC; May 25, 1949.

"The Problem of Producing a Television Program," by R. Rider, Radio Station WLWC; Election of Officers; June 8, 1949.

DES MOINES-AMES

"Programming for College FM Stations," by R. B. Hull, Radio Station WOI; May 18, 1949.

HOUSTON

"Theory and Application of Radar in Marine Geophysical Prospecting," by O. E. Haley, McCollum Laboratories, Inc.; June 15, 1949.

LOS ANGELES

"Magnetic Tape Sound Recording for Kine scope Transcriptions," by R. H. Ranger, Rangertone Inc.; "The Aims and Purposes of the Motion Picture Research Council, Inc.," by W. V. Wolfe, President, Motion Picture Research Council; June 21, 1949.

MILWAUKEE

"Atomic Power Plants," by Dr. Kingdon, General Electric Company; April 6, 1949.

"A Radio Engineer Looks at Industrial Electronics," by Dr. Cook, General Electric Company; April 13, 1949.

"Engineering Aspects of the Transistor," by J. A. Morton, Bell Telephone Laboratories; April 27, 1949.

"Application of Proximity Effects in Induction Heating," by E. Bennett, Faculty of University of Wisconsin; May 4, 1949.

"Sixteen-inch Kinescope," by H. Steier, RCA; May 11, 1949.

"Electronic Control of DC Motors," by J. B. Reeves, Cutler-Hammer, Inc.; May 25, 1949.

"Audio-Frequency Transformers and Their Functions in High-Fidelity Amplifiers," by D. Schwennesen, Chief Engineer, Chicago Transformer Corporation; May 31, 1949.

*(Continued on page 40A)*

# *Do you know*

## HOW THESE 9 FACTORS AFFECT THE QUALITY OF DISC REPRODUCTION?

**1 INTERMODULATION DISTORTION?**

Intermodulation distortion—present in many types of record reproducers to a far greater degree than suspected—causes "fuzziness" in reproduction, particularly at the higher frequencies. Low intermodulation distortion is essential for *clean* reproduction.

**2 TRANSLATION LOSS?**

When record groove velocity decreases (as the stylus moves closer to the center pin) a loss in high frequency reproduction occurs. To keep this "translation loss" to a minimum, stylus tip radius, stylus force and mechanical reactance must be in correct balance.

**3 STYLUS FORCE?**

While low stylus force is desirable to lengthen life of records, *too* low a force frequently results in inability of the reproducer to track properly at high frequencies. This, in turn, produces high intermodulation distortion. Stylus force should be kept to the lowest value consistent with proper tracking.

**4 MECHANICAL IMPEDANCE?**

For a given stylus force, low mechanical impedance in the reproducer stylus improves tracking at both low and high frequencies. Both ends of the recorded spectrum are therefore reproduced with less distortion.

**5 UNWANTED OUTPUT?**

On lateral recordings, the pick-up unit should not reproduce the unwanted vertical output which can result from surface irregularities, turntable vibrations and riding up of stylus on groove walls. Conversely, on vertical recordings, the pick-up unit should not reproduce the unwanted output caused by lateral stylus motion.

**6 ARM RESONANCE?**

The reproducer arm should not have resonant points within the spectrum of frequencies normally reproduced. If the resonant frequency of the arm is within the range of frequencies on the transcription or record, the resonant vibration of the arm will cause a spurious response.

**7 FREQUENCY COMPENSATION?**

The reproducing equipment must provide the correct frequency compensation for the recording characteristics most commonly used. Since different recording companies use widely varying characteristics, a correspondingly wide choice of equalization characteristics must be available.

**8 SCRATCH EQUALIZATION?**

A choice of scratch equalization is also necessary to meet the surface noise conditions of all records. "Rolloff" of reproducing curves must permit maximum scratch reduction while retaining as much as possible of the original material on the record.

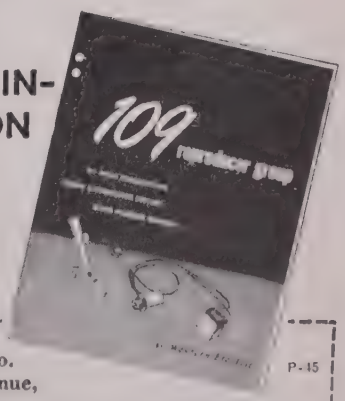
**9 NOISE PICK-UP?**

The signal-to-noise ratio must not be impaired by induced noise pick-up in the reproducer or equalizing circuits. Design of the equalizer and repeating coil should minimize hum pick-up from motor fields or other sources.

### How does the 109 Type Group stack up against these reproducer requirements?

Western Electric has just issued a 12-page bulletin explaining in greater detail the importance of these nine factors in high-quality reproduction—and showing just *why* the design of the 109 Type Reproducer Group results in outstanding performance. You'll want to have all these facts when you select reproducing equipment!

**CALL YOUR LOCAL GRAYBAR REPRESENTATIVE FOR A COPY OF THIS NEW BULLETIN—OR MAIL COUPON BELOW**




# Western Electric

— QUALITY COUNTS —

Distributed by Graybar — OFFICES IN 100 PRINCIPAL CITIES

**DISTRIBUTORS:** IN THE U.S.A.—Graybar Electric Co. IN CANADA—Northern Electric Company, Ltd.

Graybar Electric Co.
420 Lexington Avenue,
New York 17, N. Y.

P-45

*Gentlemen: Please send me a copy of Bulletin T2551, "109 Reproducer Group."*

*Name* _____

*Title* _____

*Company* _____

*Street Address* _____

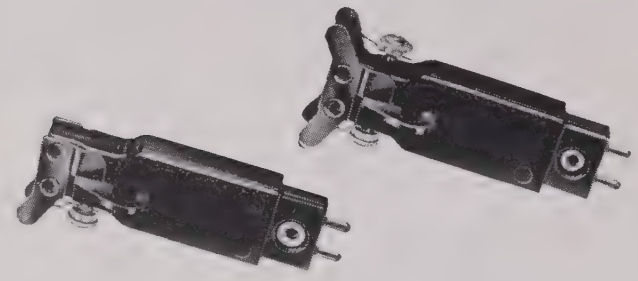
*City* _____ *State* _____

The little SHURE cartridges

that fill the Big need

for High Fidelity

Phonograph Reproduction . .



THE NEW SHURE "VERTICAL DRIVE"

CRYSTAL PICKUP CARTRIDGES

Big things often come in little packages . . . So it is with the superlative new Shure "Vertical Drive" Crystal Cartridges. They reproduce *all* the recorded music on the new fine-groove recordings—a reproduction that meets the strict requirements of high compliance and full fidelity. The "Vertical Drive" cartridges are requisite for the critical listener—the lover of fine music. They are especially recommended for those applications where *true fidelity* is essential.

| | |
|---|---|
| SINGLE MODELS: | W23A for standard width - groove records.<br>W21A for fine-groove records. |
| TURNOVER MODEL: | W22A for both standard and fine-groove recordings. |

Unusually highly compliant, these "Vertical Drive" Cartridges will faithfully track standard records with a force of only 7 grams—micro-groove records with a force of only 5 grams (an added protection for treasured recordings). Will fit standard or special mountings. Have more than adequate output for the average audio stage.

SHURE

SHURE BROTHERS, INC.

*Microphones and Acoustic Devices*

225 WEST HURON STREET, CHICAGO 10, ILL. • CABLE ADDRESS: SHUREMICRO


## SECTION MEETINGS

*(Continued from page 38A)*

Ladies Night; Ventriloquist; Movies; and Election of Officers; June 9, 1949.

NEW MEXICO

"Theory and Practice of Strategic Bombing in World War II," by A. W. Baldyreff, Faculty of University of New Mexico; Election of Officers; June 17, 1949.

NORTH CAROLINA-VIRGINIA

"Electrical Measurements of Force and Pressure," by D. H. Newby, National Advisory Committee for Aeronautics; "Application of Radio Telemetering to Aeronautical Research," by C. A Taylor, National Advisory Committee for Aeronautics; Inspection Trip of Instrument Laboratories, National Advisory Committee for Aeronautics; June 24, 1949.

PHILADELPHIA

"A Record Changer and Record of Complimentary Design," by H. I. Reiskind and A. D. Burt, RCA Victor Division; May 5, 1949.

SAN DIEGO

"The Ultrasonics Research Program at Brown University," by R. B. Lindsay, Faculty of Brown University; July 12, 1949.

SAN FRANCISCO

"Electronic Digital Computors," by P. L Norton, Faculty of University of California; May 11, 1949.

Student Papers Competition; "Ion Beam Integrator," by K. D. Jenkins, Student, University of California; "Electronic Flux Meter," by F. B. Gallagher, Student, Santa Clara University; "High-Power Limitations of a Traveling-Wave Tube," by D. Dunn, Student, Stanford University; Election of Officers; June 8, 1949.

TWIN CITIES

"Music Reproduction," by J. D. Goodell, President, The Minnesota Electronics Corporation; June 16, 1949.

WASHINGTON

"Stratovision," by C. E. Nobles, Westinghouse Electric Corporation; June 13, 1949.

*SUBSECTIONS*

LONG ISLAND

Election of Officers; April 27, 1949.

MONMOUTH

"Image Quality in Photography and Television," by O. H. Schade, RCA, June 15, 1949.

LANCASTER

Tour of Safe Harbor Dam and Power Plant; May 11, 1949

## MEMBERSHIP

**The following transfers and admissions were approved and will be effective as of September 1, 1949.**

### Transfer to Senior Member

Chapin, R. S., 383 Lake St., Lake Garda, Unionville, Conn.

Finney, W. J., Bldg. 1, Rm. 213, Naval Research Laboratory, Washington 25, D. C.

*(Continued on page 42A)*

# 2 new metal "Big Picture" tubes by Rauland!

## AVAILABLE WITH NEW HIGH-CONTRAST LUXIDE SCREEN

Gives 60% greater contrast! Reduces glare! Gives sharper, easier-to-view pictures!

## 50% LIGHTER WEIGHT

Can be safely shipped installed in sets, reducing field installation costs.

**LARGER SCREEN**

105 square inches useful screen area

**LOWER PRICE**

Lower bulb cost permits lower prices

**BETTER FACE QUALITY**

Optical quality of metal tube faces is superior to the pressed faces of all-glass tubes.

**SHORTER LENGTH**

2⅝" shorter than the 16AP4

**USES AVAILABLE OPERATING COMPONENTS**

Same focus and deflection coils as used with the 16AP4

**ALLOWS IMPROVED CABINET DESIGN AND LOWER CABINET COST**

Because of reduced cabinet depth requirement

Other Available Types—10BP4, 10FP4, 12LP4, 12KP4, 16AP4

WRITE FOR TECHNICAL BULLETINS

*"Perfection through Research"*

THE **Rauland** CORPORATION

4245 N. Knox Avenue • Chicago 41, Illinois

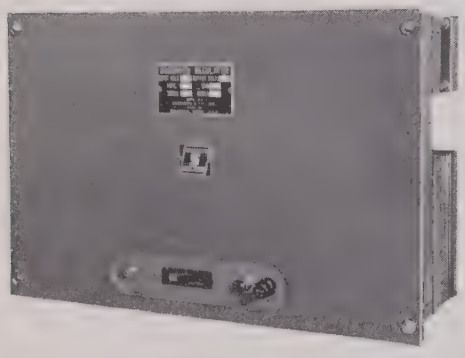
# "WANT TO KNOW WHY I'M SOLD ON *sorensen*?"

"Voltage regulators — even *electronic regulators* — are not all equally accurate! And I know ACCURACY is important! The Sorensen electronic voltage regulator gives me the *kind of accuracy* I want.

"But I don't want to buy accuracy and costly maintenance at the same time. The Sorensen Regulator is a strong rugged instrument designed to give accuracy at no sacrifice to low-cost-of-maintenance.

"Furthermore I like my instruments simple — well designed — because I know that a complex instrument loaded with added components can mean poor basic design — and inferior performance. The Sorensen Electronic Voltage Regulator is a beauty for simplicity."

"That's why I'm sold on ***sorensen***"

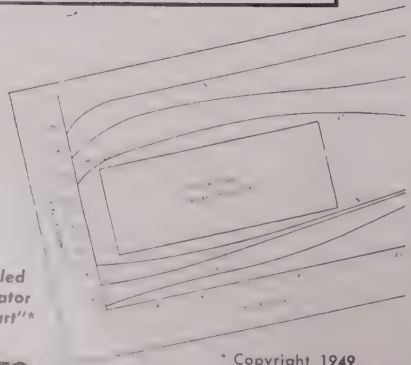


***Get highly stabilized DC regulation with the NOBATRON and B-NOBATRON.***

## STANDARD AC SPECIFICATIONS

| Model in VA Capacity | | 150<br>500 | 250<br>1000 | 2000<br>3000 | 5000<br>10000<br>15000 |
|---|---|---|---|---|---|
| Regulation Accuracy | | ± 0.1% against line or load | | | |
| Harmonic Distortion | Basic | 5% max. | 5% max. | 5% max. | 5% max. |
| | S | 3% max. | 2% max. | 3% max. | 3% max. |
| Input Voltage | | 95-130 VAC; also available for 90-260 VAC single phase 50-60 cycles | | | |
| Output Voltage | | Adjustable between 110-120; 220-240 in 230 VAC models | | | |
| Load Range | | 0 to full load | | | |
| P.F. Range | | Down to 0.7 P.F: all S models temperature compensated | | | |
| NOTE: REGULATORS CAN BE HERMETICALLY SEALED | | | | | |

**The ORIGINAL SORENSEN CIRCUIT is easily adapted to meet your special requirements. SORENSEN engineers are always available to solve any unusual problem not handled by the STANDARD SORENSEN LINE. JAN requirements can be met by all models.**



*Write for detailed "Sorensen Regulator Performance Chart"*

Sorensen and company, inc.

375 Fairfeld Ave., Stamford, Conn.

* Copyright 1949


# MEMBERSHIP

*(Continued from page 40A)*

Hammond, G. H., 66 Old Billerica Rd., Bedford Mass.
Hebenstreit, W. B., Hughes Aircraft Company, Culver City, Calif.
Hodgson, A. D., Barnes Bldg., Bridge St., Bridgetown, Barbados, B.W.I.
Linder, E. G., RCA Laboratories, Princeton, N. J.
Margosian, J. W., 75-34 113 St., Forest Hills, L. I., N. Y.
Miller, G. A., 30 Sunset Blvd., Ottawa, Ont., Canada
Ottemiller, W. H., Jr., R.D. 1, Seneca Falls, N. Y.
Robins, B. W., 6021 Upsal St., Pennsauken, N. J.
Suffield, F. G., 333 15 St., Manhattan Beach, Calif.
Todd, S. R., 4711 Woodlawn Ave., Chicago 15, Ill.
Winter, H., 3514 E. Thaxton Ave., Albuquerque, N. Mex.

### Admission to Senior Member

Brueckmann, H. L., 372 W. Park Ave., Oakhurst, N. J.
Franklin, W. S., 3123 N. Pulaski Rd., Chicago 41, Ill.
Harrison, C. E., 4530a W. Papin, St. Louis 10, Mo.
Horton, A. W., Jr., 463 West St., New York 14, N. Y.
Pearce, J. M., Electronics Section #355, The Glenn L. Martin Company, Baltimore 3, Md.
Stiles, K. P., 106 Prospect St., Summit, N. J.

### Transfer to Member

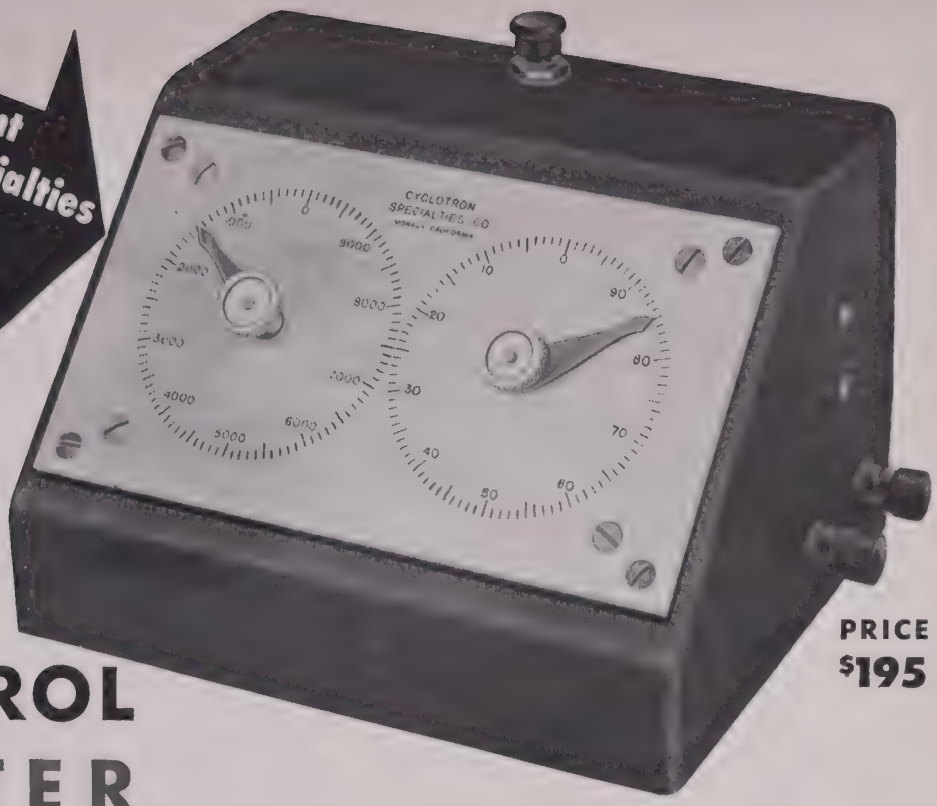
Ahrens, G. W., 2402 Avenue P, Galveston, Tex.
Anderson, R. M., 4315 Virginia, Kansas City, Mo.
Eastman, J. W., 4607 Harwood Dr., Des Moines 12, Iowa
Flynn, G., Radio Station WOW, Insurance Bldg., Omaha 2, Neb.
Franco, M., 527 N. Mott St., Los Angeles 33, Calif.
Hoff, K., c/o Stremsheim, Vei 2884, Oslo, Norway
Karanjia, K. F., Patel Mansion, DeLisle Rd., Lower Parel, Bombay, India
McFadden, H. W., 1244 Dufferin St., Toronto 4, Ont., Canada
Monroe, W. J., Box 1581, New Orleans, La.
Moore, H. H., 3601 College Ave., Kansas City 3, Mo.
Nicholson, T., 3614 E. 57 St., Kansas City 4, Mo.
Phillips, F. S., 809 W. 32 St., Houston 8, Tex.
Russ, W. E., 1503 S. Harvey Ave., Berwyn, Ill.
Seigle, R. K., 1 Ash Dr., Great Neck, L. I., N. Y.
Srivastava, T. N., Asst. Divisional Engineer Telegraphs, Eastern Court, New Delhi, India
Threadgill, A. R., 103 Kenwyn Rd., Oak Ridge, Tenn.
White, M. F., 465 W. 162 St., New York 32, N. Y.

### Admission to Member

Basavaraju, T. V., 500 Riverside Dr., New York 27, N. Y.
Capron, R. W., 3407 Trumbull Ave., Detroit 8, Mich.
Chaffee, M. A., 5 Brookwood St., Glen Head, N. Y.
Crain, C. M., Engineering Bldg. 149, University of Texas, Austin, Tex.
Deise, L. F., 1901 E. 31 St., Baltimore 18, Md.
Durkee, C. H., 1 Sylvan Lane, Old Greenwich, Conn.
Firestone, W. L., 846 W. Montrose, Chicago 13, Ill.
Gerhold, R. A., 1680 Metropolitan Ave., New York 62, N. Y.
Goerke, V. H., National Bureau of Standards, APO 942, c/o Postmaster, Seattle, Wash.
Greene, J. C., 2327 Rosedale St., Baltimore 16, Md.
Hart, S. V., Industrial Electronics, Inc., 2457 Woodward Ave., Detroit 1, Mich.

*(Continued on page 44A)*

**A New Instrument by Cyclotron Specialties for Controlling Mechanical Cycles**




**PRICE $195**

# CYCLO-TROL REGISTER

The **CYCLO-TROL*** Register is the latest addition to the well-known line of Cyclotron Impulse Registers. The same principle of operation which has gained for these registers such wide use and recognition is applied in this new unit to provide accurate control over a wide range of mechanical cycles.

The **CYCLO-TROL** Register has two calibrated dials which can be instantly set by means of shaft thumbscrews to any number from 0 to 10,000. When pulsed by an external circuit, the **CYCLO-TROL** continues to register until the preset number of counts is reached. At this point, **CYCLO-TROL's** output circuit is completed and a contact is made to external circuit, thus actuating, as desired, operation under control.

The **CYCLO-TROL** can be reset to original setting by merely pressing the button on top of register. By this simple step, repeat cycles of control can be secured as many times as desired.

## SPECIFICATIONS AND SPECIAL FEATURES

| | |
|---|---|
| **Counting Rate:** | 60 impulses per second maximum |
| **Power Source:** | 115 volts A.C. |
| **Power Supplied to Impulse Contact:** | 110 volts D.C.—self-contained |
| **Output Circuit:** | 50 volts D.C. (direct or to auxiliary relay) |
| **Dimensions:** | 7"x 4"x 4" high |
| **Weight:** | 5 pounds (approx.) |

## APPLICATIONS OF CYCLO-TROL REGISTER

The **CYCLO-TROL** Register is made available because of insistent demand from users of other types of Cyclotron Specialties Registers. Here are only a few of the many applications of this new unit—

- ★ Counting problems involving positive, accurate control over any number of revolutions or cycles up to 10,000.
- ★ Electrical circuits may be opened or closed at any predetermined number of counts.
- ★ **Ideal for coil winding machines.** The exact number of turns can be preset and machine stopped at exact point, making possible any number of identical coils. Operator needn't watch counter...his attention can be concentrated on winding.

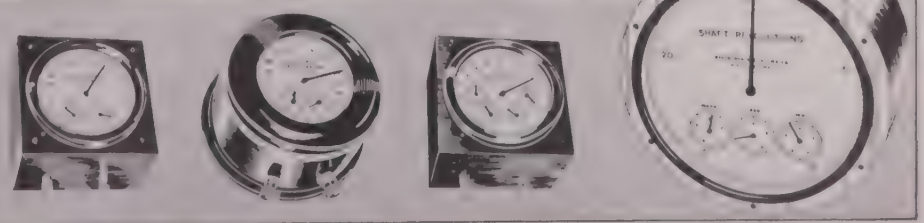
*Trade Mark

Immediate Delivery in Reasonable Quantities

**Cyclotron Specialties Company**

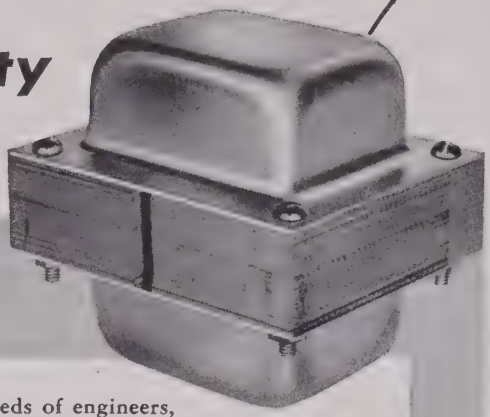
MORAGA 10, CALIFORNIA

**Made by the Manufacturers of these Famous Impulse Registers**



# New Yeoman TRANSFORMER

**gives you ADC Quality at LOW COST**



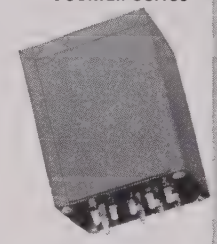
Designed to meet the needs of engineers, experimenters and amateurs who demand high quality at low cost, the new **ADC** Yeoman line provides many of the well-known performance standards of the Quality Plus and Industrial series, also several items not previously offered. This has been accomplished primarily by improved production engineering methods, standardization of parts and a simplified type of construction.

**The ADC Yeoman line includes:**

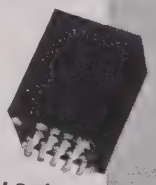
- Output Transformers with carefully balanced windings offering unusually low distortion over a wide frequency range.
- Interstage Transformers with balanced humbucking features providing equal push-pull grid voltages at high audio frequencies for inverse feedback circuits.
- Power Transformers limited to 55°C. temperature rise and especially quiet in operation.
- Replacement Units for Audio and TV circuits, miniatures, filament transformers, reactors, and many others.

**ADC** *invites your critical appraisal of this new Yeoman line.*

*Yeoman Series*



*Quality Plus Series*



*Industrial Series*

*Audio Develops the Finest*

Send for the new **ADC** catalog which you will find convenient to use in selecting almost any transformer you may need. Special requirements not covered by the catalog will receive prompt attention.

**ADC** *Audio* **DEVELOPMENT CO.**
2855 - 13th AVENUE SOUTH, MINNEAPOLIS 7, MINN.


## MEMBERSHIP

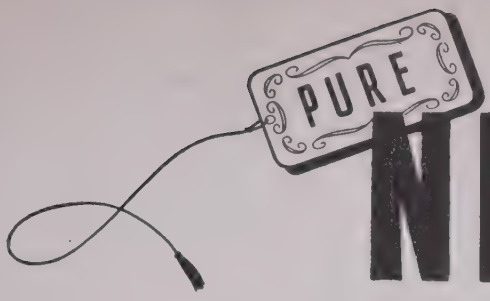
*(Continued from page 42A)*

Ingraham, K. R., Director Telecommunications, Box 48, Nassau, Bahamas
Keyes, J. C., 414A Nimitz Ave., China Lake, Calif.
Kubicek, W. G., Dept. of Physical Medicine, Medical School, University of Minnesota, Minneapolis 14, Minn.
Lambert, C. O., 758-B Crane Walk, Akron 11, Ohio
Neelands, L. J., 117 Parkside Ave., Syracuse, N. Y.
Neubauer, J. R., 3118 Dillon Ave., Cheyenne, Wyo.
Obermuller, W. F., Caixa Postal 2726, Rio De Janeiro, Brazil
Shama Rao, P. L., 124 Sri Krishnarajendra Rd., Basavangudi, Bangalore, South India
Toufexis, S., The Delehanty Radio Institute, 105 E. 13 St., New York 3, N. Y.
Wembold, R. F., 480 E. 23 St., Brooklyn 26, N. Y.

**The following admissions to Associate were approved and are effective as of August 1, 1949:**

Aarons, C. R., 631 W. Ellet St., Philadelphia, Pa.
Arnold, A., Jr., 6026 Madison St., West New York, N. J.
Bantin, W. F., 4166 St. Catherine St., W., Montreal, Que., Canada
Beiser, F. D., 532 Thatcher, River Forest, Ill.
Bell, W. I., R.D. 1, Coatesville, Pa.
Bergman, L. C. H. M., Government Radio and Telephone Administration, Willemstad Curacao, Netherlands West Indies
Boyd, D. B., General Delivery, Hilliards, Pa
Bryant, R. M., Jr., Pines Lake E., Box 307, Paterson, N. J.
Buck, D. T., 37-41 Marcy St., Freehold, N. J.
Dula, J. E., 10217 Ave. M, Chicago 17, Ill.
Edens, R. L., 1015 S. Fifth St., Waco, Tex.
Eslava, E. R., Apartado Postal No. 1106, Bogota, Columbia
Fujimoto, J. J., 5327 N. Winthrope Ave., Chicago 40, Ill.
Gatch, C. E., Box 444, St. George, S. C.
Ghose, B. N., 11-42 Panditia Rd., Ballygunge, Calcutta 29, India
Goddard, C. A., 6517 Kimbark Ave., Chicago 37, Ill.
Gudzin, M. G., 3259 Queenstown Dr., Mt. Rainier, Md.
Hall, F. C., 5331 W. Congress, Chicago 44, Ill.
Hall, R. E., 43 Leon St., Boston 15, Mass.
Harris, R. B., Taylor Instrument Co., 95 Ames St., Rochester 1, N. Y.
Hodgkinson, W. S., 58 Adella Ave., West Newton, Mass.
Holt, C., III, Box 1372, Wright Patterson A.F.B., Dayton, Ohio
Hooper, F. E., 1120 19 St., S., Arlington, Va.
Iannotti, J. D., 606 W. South St., Angola, Ind.
Johnston, J. L., 223 W. Park, Pittsburg, Kan.
Kilpatrick, L. L., 3981 Menlo Ave., Los Angeles 37, Calif.
King, R. L., Box 313, Lockbourne A.F.B., Columbus 17, Ohio
Knox, R. M., 818-B S. Catalina Ave., Redondo Beach, Calif.
Kofler, E. J., 1409 Franklin St., Racine, Wis.
Lambert, R. L., 550 Arlington Pl., Chicago 14, Ill.
Lombard, W. A., 2560 Lalla St., Beaumont, Tex.
Marchetta, P., ASW Branch, Aeel Nads, Johnsville, Pa.
Marheine, E. A., 2173 N. 70 St., Wauwatosa 13, Wis.
Marsh, S. V., 1308 W. Rosedale St., Chicago 40, Ill.
Mattern, J., 1724 Patton Dr., Schenectady 7, N. Y.
Mehta, O. N., 2 Royal Hotel, Jubbilpore C. P., India
Mohan, M. A., Tech. Officer, Civil Aviation Dept., Radio Development Unit, Factory Rd., New Delhi, India

*(Continued on page 47A)*




# NICKEL

*Sheet, Strip, Rod, Wire, Tubing, Clad-steel, Castings.*

## Its practical cost astonishes users almost as much as its distinctive characteristics

### CHEMICAL COMPOSITION

The nominal composition of commercially pure wrought Nickel is:

| | |
|---|---|
| Nickel* | 99.4% |
| Copper | 0.1 |
| Iron | 0.15 |
| Manganese | 0.2 |
| Silicon | 0.05 |
| Carbon | 0.1 |

**Including cobalt*

### PHYSICAL CONSTANTS

| | |
|---|---|
| Specific Gravity | 8.89 |
| Density, lb. per cu. in. | 0.321 |
| Melting Point | 2615-2635°F. / 1435-1445°C. |
| Specific Heat at (80-212°F.) | 0.130 |
| Heat Expansion Coefficient at (80-212°F.), per °F | 0.0000072 |
| Thermal Conductivity at (80-212°F.), Btu/sq. ft./hr./°F./in. | 420 |
| Electrical Resistivity at 32°F., ohms/cir. mil. ft. | 63 |
| Temperature Coefficient of Electrical Resistivity per °F | 0.0022-0.0028 |
| Modulus of Elasticity in tension, psi | 30,000,000 |
| in torsion, psi | 11,000,000 |
| Poisson's Ratio | 0.31 |

### MECHANICAL PROPERTIES

The following figures for Standard Cold Rolled Sheet are typical, though the figures will vary for different forms and tempers.

| | |
|---|---|
| Tensile Strength | 55,000-80,000 psi |
| Yield Strength (2% offset) | 15,000-45,000 psi |
| Elongation in 2 in. | 50-35% |
| Rockwell B Hardness | 40-70 |

### AVAILABLE FORMS

| | | | |
|---|---|---|---|
| Wire | Bar | Plate | Pipe |
| Rod | Angles | Sheet | Strip |

Seamless and Welded Tubing
Sand and Precision Castings
Clad-Steel Plate and Strip Welding Rods

***It is a strange and interesting metal, Pure Nickel. A kin of both the base metals and the precious metals. Among all the elements, no other metal possesses its unique combination of so many different and uncommon properties.***

- It is highly resistant to corrosives that destroy many other metals—alkalies, many acids, salts, organic compounds, fumes.
- It has mechanical properties like those of structural steel.
- Yet it is so ductile that it can be worked into the most intricate and delicate shapes that are practical in metal.
- It protects the purity of sensitive foods, beverages and pharmaceuticals against contamination.
- It often provides a faster rate of heat transfer than metals with equal heat conductivity.
- Its special electronic properties make it a standard metal for electronic uses.
- It offers rare electrical and magnetostrictive characteristics that often give theoretical ideas a birth of practical value.
- It can be exposed to temperatures ranging into yellow heat and even hotter in the absence of sulphur.
- At sub-zero temperatures its strength increases without change in ductility and toughness.
- It is a standard metal for the cladding of steel, and as a base for gold, palladium and silver-clad products.

***And one of the most valuable of all its features is the fact that Pure Nickel is a practical metal at a practical price.***

***Does it stimulate an idea of how you may find an easy answer to a difficult problem?***

***Our booklet, "Inco Nickel Alloys for Electronic Uses" gives the important facts you want. It's yours for the asking.***

**The International Nickel Company, Inc.**

67 Wall Street, New York 5, N.Y.

*(left)*

For high voltage power supply circuits of television receivers, specify our #102 COSMALITE COIL FORM. Note the sturdy, heavy-wall construction . . . the clean-cut, accurate, punched holes and notches. Ask about the many other advantages of these outstanding Cosmalite Coil Forms.

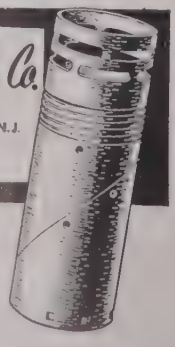
*(right)*

COSMALITE COIL FORMS WITH COLLARS, made from our #96 Cosmalite, are a fibre base phenolic tubing, also of the highest quality at the lowest production cost. Specify that the collars be included and positioned on the core and thus secure a snug fit and an electrically stronger assembly.

**COSMALITE is a proven product backed by over 25 years of experience.**

*Reg. U. S. Pat. Off.

The CLEVELAND CONTAINER Co.
6201 BARBERTON AVE. CLEVELAND 2, OHIO
PLANTS AND SALES OFFICES at Plymouth, Wisc., Chicago, Detroit, Ogdensburg, N.Y., Jamesburg, N.J.
ABRASIVE DIVISION at Cleveland, Ohio
CANADIAN PLANT: The Cleveland Container, Canada, Ltd., Prescott, Ontario



REPRESENTATIVES

| | |
|---|---|
| CANADA | WM. T. BARRON, EIGHTH LINE, RR #1, OAKVILLE, ONTARIO |
| METROPOLITAN NEW YORK | R. T. MURRAY, 614 CENTRAL AVE., EAST ORANGE, N.J. |
| NEW ENGLAND | E. P. PACK AND ASSOCIATES, 968 FARMINGTON AVE WEST HARTFORD, CONN. |

BEAUMONT-PORT ARTHUR

"Naval Reserve Communications," by Commander C. B. Trevey, USNR; July 28, 1949.

CEDAR RAPIDS

"Engineering Aspects of the Transistor," and "A New Microwave Tube," by R. M. Ryder, Bell Telephone Laboratories; April 25, 1949

INDIANAPOLIS

"A Record Changer and Record of Complementary Design," by W. W Webber, RCA Victor Division; March 25, 1949.

"Phase Distortion in Audio Systems," by L. A. Di Rosa, Federal Telecommunications Laboratories; and Election of Officers; April 22, 1949.

"Transistors," by J. A. Morton, Bell Telephone Laboratories; April 29, 1949.

"Noise Filters," by R. O. Lewis, Lewis Engineering Company; May 27, 1949

NEW MEXICO

"A Visual Method of Audio Frequency Analysis," by L. E. Boltz, Student; "Directional Antennas for the Broadcast Band," by F. P. Stoklas, Student; May 13, 1949.

"Problems of Television Installation, Maintenance, Testing, and Personnel Training in New Mexico," by G. S. Johnson, Manager and Chief Engineer of Radio Station KOB-TV; July 15, 1949.

SACRAMENTO

"Status of Television in Northern California," by A. Isberg, Chief Engineer, San Francisco Chronicle Television Station; May 10, 1949.

"Broadcast Quality Magnetic Tape Recording," by W. B. Fletcher, RCA Service Company, May 24, 1949

SAN DIEGO

"Radio Astronomy," by C. R. Burrows, Director, School of Electrical Engineering, Cornell University; August 2, 1949.

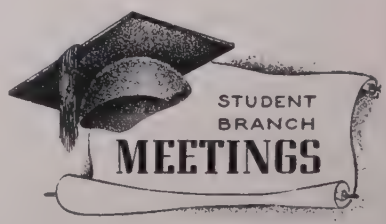
TOLEDO

"Broadcast Studio Mixing and Switching Systems," by A. Friedenthal, Radio Station WJR; and Election of Officers; June 20, 1949.

*SUBSECTIONS*

AMARILLO-LUBBOCK

"Fundamentals of Radio," by C. E. Houston, Faculty of Texas Technological College; June 14, 1949




ALABAMA POLYTECHNIC INSTITUTE—IRE BRANCH

"Three-Dimensional Presentations on C-R Oscilloscope," by A. A. Caldwell, Student; July 18, 1949.

"Low-Level Audio Circuit Problems," by J. M. Walters, Student; Film on Electronic Tubes; August 1, 1949

*(Continued on page 36A)*

WILCOX ...First Choice

**of WISCONSIN CENTRAL AIRLINES**

**WIS completely equips all ground stations and aircraft with *WILCOX* radio**

***VHF AIR-BORNE COMMUNICATIONS***

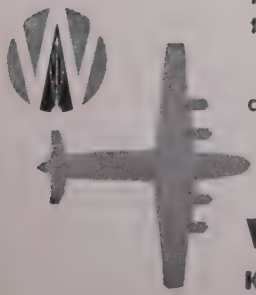
WILCOX TYPE 361A—50 watt transmitter, high sensitivity receiver, and compact power supply—each contained in a separate ½ ATR chassis. Receiver and transmitter contain frequency selector with provisions for 70 channels...ample for both present and future needs.

***VHF GROUND STATION PACKAGED RADIO***

WILCOX TYPE 378A—Complete with Type 364A, 50 watt transmitter, 305A Receiver, common antenna, telephone handset and loudspeaker, desk front, message rack and typewriter well. Type 411A LF Transmitter may be installed in the same cabinet for radiobeacon facilities.

***MULTI-FREQUENCY GROUND STATION TRANSMITTER***

WILCOX TYPE 99A—Provides simultaneous transmission on LF, MHF, and VHF, frequencies. Housed in a single steel cabinet, the rectifier, modulator, remote control, and 4 transmitting channels combine to make the most compact multi-frequency transmitter in the 400 watt field.



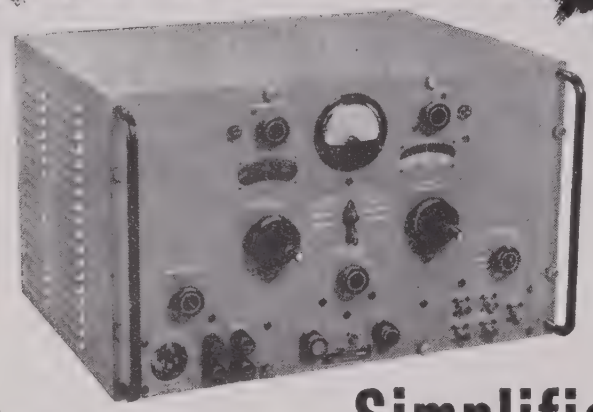
***WRITE TODAY***...for complete information on all types of point-to-point, air-borne, ground station, or shore-to-ship communications equipment.

**WILCOX ELECTRIC COMPANY**

KANSAS CITY MISSOURI

AIRCRAFT
RADIO
CORPORATION

Type H-12
SIGNAL GENERATOR
900-2100 MEGACYCLES



–Simplified
–Compact
–Portable

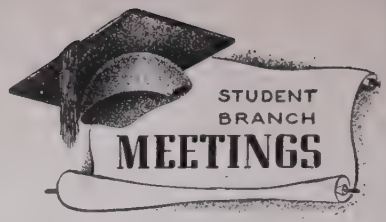
Built to Navy Specifications for research and production testing

- 900-2100 megacycles, single band
- Directly calibrated, single dial frequency control
- Directly calibrated attenuator, 0 to –120 dbm
- CW or AM pulse modulation
- Internal pulse generator with controls for width, delay, and rate. Provision for external pulsing
- Controls planned and grouped for ease of operation
- Weight: 42 lbs. Easily portable—ideal for airborne installations
- Immediate delivery

*Write for specifications — investigate the advantages of this outstanding new instrument.*

DEPENDABLE ELECTRONIC EQUIPMENT SINCE 1928

Aircraft Radio Corporation
BOONTON, New Jersey




*(Continued from page 34A)*

CALIFORNIA STATE POLYTECHNIC COLLEGE—IRE BRANCH

Election of Officers; April 11, 1949.

"Applications of Digital Computers," by S. P. Frankel, Faculty of California State Polytechnic College; May 16, 1949.

UNIVERSITY OF DAYTON—IRE BRANCH

"Electronic Control of Magnetic Coupling," by Tom Holloran, Student; April 5, 1949.

"Electronically Operated Voltage Regulators," by Bob Burtner, Student; April 19, 1949.

"Properties of Wide-Band Phase-Splitting Networks," by Frank Raucher, Student; April 26, 1949.

Election of Officers; May 10, 1949.

UNIVERSITY OF LOUISVILLE—IRE BRANCH

"Field-Strength Measurements," by D. C. Summerford, Technical Director of Radio Station WKLO; May 26, 1949.

Film: Crystal Clear, Industrial Measurements, and Stepping Along with Television; July 28, 1949.

**The following transfers and admissions were approved and will be effective as of October 1, 1949:**

### Transfer to Senior Member

Albertson, F. W., Dow, Lohnes and Albertson, Munsey Bldg., Washington 4, D. C.
Brown, M. H., 14851 Wadkins Ave., Gardena, Calif.
Bunday, D. L., 2316 Carnation, Fort Worth 11, Tex.
Gihring, H. E., 5103 Westwood Lane, Merchantville, N. J.
Kerr, E. J., C.S.I.R., Radiophysics Laboratory, University Grounds, City Rd., Chippendale, Sydney, N.S.W., Australia
Muniz, R., 154 Mortimer Ave., Rutherford, N. J.
Stevens, S. S., 225 Overdale St., St. James, Man., Canada
Teachman, A. E., 102 Bynner St., Jamaica Plain, Boston, Mass.
Zelle, J. F., 1227 Addison Rd., Cleveland 3, Ohio

### Admission to Senior Member

Ainsworth, M. J., 17544 Raymer St., Northridge, Calif.
Coltman, J. W., 256 Cascade Rd., Pittsburgh 21, Pa.
Gormley, R. S., 40 High St., Glen Ridge, N. J.
Hollis, W. C., 458 77 St., Brooklyn 9, N. Y.

### Transfer to Member

Andersen, A., 103 Osborne Ave., Baltimore 28, Md.
Cline, D. E., 75 Morris Ave., Manasquan, N. J.
Dasgupta, S. M., Government Engineering College, Jubbulpore, C.P., India
Ganguly, S. K., 19 Chakrabere Rd., S., Calcutta 25, India
Harmatuk, S. N., 1575 Odell St., New York 62, N. Y.

*(Continued on page 37A)*

## MEMBERSHIP

*(Continued from page 36A)*

Hulse, B. T., Physics Dept., University of Wyoming, Laramie, Wyo.
McNulty, J. W., 2500 Noble Ave., Alamedo, Calif.
Meth, I., 612 Marcy Ave., Brooklyn 6, N. Y.
Pittsley, E. L., R.D. 1, Reynolds Rd., Johnson City, N. Y.

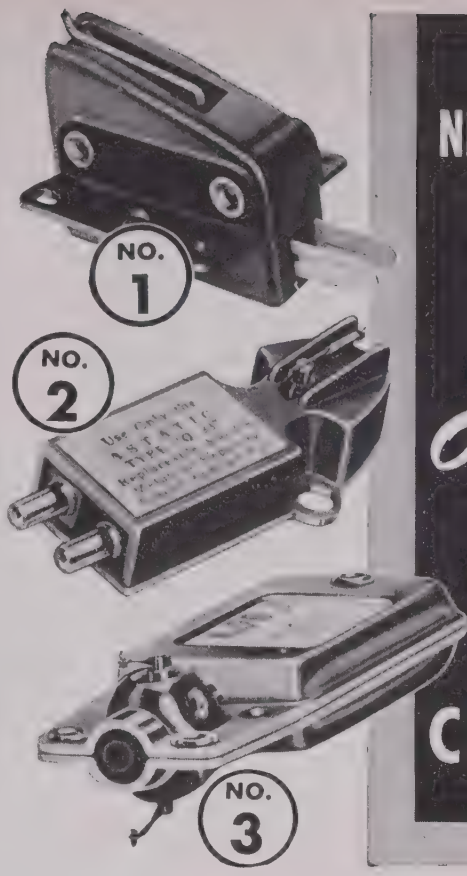
### Admission to Member

Bastow, W. R., 5 Sherwood Rd., Natick, Mass.
Bowles, M. E., 3056 McFarlin Blvd., Dallas 5, Tex.
Creaser, C. W., Jr., 62 Stockdale Rd., Needham, Mass.
Grobler, J. J., Box 31, Benoni, Transvaal, South Africa
Jacobson, R. E., Jr., 2814 E. Silver Ave., Albuquerque, N. Mex.
Larranaga, G. A., Uruguayan Naval Mission, 261 Constitution Ave., N.W., Washington, D. C.
Mallory, W. M., Electrical Engineering Dept., University of Wyoming, Laramie, Wyo.
McCoy, F. G., 23A Savage St., Charleston 4, S. C.
Mitra, A. K., Communication Officer, Aero Communication Station, Dum Dum Airport, India
Secan, H., Kollsman Instrument Division, 80-08 45 Ave., Elmhurst, L. I., N. Y.
Sherman, R. L., 324th Strategic Reconnaissance Squadron, McGuire Air Force Base, N. J.
Srivastava, S. S., Bayswater Hall, 46 Kensington Gardens Sq., London W. 2, England

**The following admissions to Associate were approved, to be effective as of September 1, 1949:**

Aleo, J., 2212 Aerial St., Dayton 9, Ohio
Allen, C. A., 403 S. Third St., Homer, La.
Allen, R. C., Jr., 131 Washington Pl., Ridgewood, N. J.
Anderson, F. A., 1294 Eighth Ave., Sacramento 14, Calif.
Anderson, W. L., 185 Gundry Dr., Falls Church, Va.
Andrew, R. T., 121 East St., Wrentham, Mass.
Archer, J. R., 4145 Sheridan Rd., Chicago 13, Ill.
Bartolomei, H., 2043 Central Ave., Alameda, Calif.
Beck, W. R., 1415 S. Orange Grove, Los Angeles 35, Calif.
Bellis, R. P., 50 Ganesvoort Blvd., Staten Island, N. Y.
Best, J. G., 1142 W. Beardsley Ave., Elkhart, Ind.
Boyan, M. J., 4245 Magoun Ave., East Chicago, Ind.
Butler, G. T., Jr., Rm. 1301, YMCA, Dayton 2, Ohio
Chester, C. L., 3902 Santa Ana, South Gate, Calif.
Clark, R. V., 14 Apple Tree Lane, Great Neck, L. I., N. Y.
Cohen, G. S., 100 Hasbrouck St., Newburgh, N. Y.
Cook, K. H., 118 W. 67 St., Kansas City, Mo.
Ducastel, G., Rue D'Erquelinnes No. 64, Jeumont, Nord, France
Edgerly, J. J., 58 10 Ave., Charleston 30, S. C.
Felix, E. A., Imperial Bank of India, Trichinopoly, Madras Province, India
Fligel, W. P., 1312 S. Maple Ave., Berwyn, Ill.
Fox, M. L., 1232 W. Pratt Blvd., Chicago 26, Ill.
Garlock, J. W., 28 Westfield St., Providence 7, R. I.
Garrett, J. C., 2610 Winona St., Chicago 25, Ill.
George, J. E., 100 W. 38 St., Kansas City 2, Mo.
Gion, J. A., 411 N. Jackson St., Glendale 6, Calif.
Girling, K. W., Barnes Bldg., Bridgetown, Barbados, B.W.I.
Gormley, P. M., Kirkhill Farm, R.D. 2, Germantown, Md.
Gould, E. W., Florence Ave. and Teale St., Culver City, Calif.
Gronroos, E. O., 25 Chapel Ct., Norwood, Mass.

*(Continued on page 38A)*


THESE THREE NEW DEVELOPMENTS ARE *Keeping* ASTATIC *Out in Front* IN THE MANUFACTURE OF PICKUP CARTRIDGES

**1 GC CERAMIC CARTRIDGE**

First major engineering stride in phonograph pickup cartridges employing ceramic elements since Astatic pioneered in this type unit last year. The GC is the first cartridge of its kind with replaceable needle. Takes the special new Astatic "Type G" needle—with either one or three-mil tip radius, precious metal or sapphire—which slips from its rubber chuck with a quarter turn sideways. Resistance of the ceramic element to high temperatures and humidity is not the only additional advantage of this new development. Output has been increased over that of any ceramic cartridge available. Its light weight and low minimum needle pressure make it ideal for a great variety of modern applications.

**2 CQ CRYSTAL CARTRIDGE**

An entirely new Astatic design, featuring miniature size and five-gram weight. Model CQ-J fits standard 1/2" mounting and RCA 45 RPM record changers. Model CQ-1J fits RMA No. 2 Specifications for top mounting .453" mounting centers. Needle pressure five grams. Output 0.7 volts at 1,000 c.p.s. Employs one-mil tip radius, Q-33 needle. Cast aluminum housing.

**3 LQD Double-Needle Crystal Cartridge**

The LQD Cartridge—for 45, 33-1/3 and 78 RPM Records—quickly became the first choice of many of the nation's largest users, on the basis of comparative listening tests, and is, today, the PROVED TOP PERFORMER for turnover type pickups. Outstanding for excellence of frequency response, particularly at low frequencies. A gentle pry with penknife removes ONE needle for replacement . . . without disturbing the other needle, without removing cartridge from tone arm. Gentle pressure snaps new needle into place. Available with or without needle guards. Stamped aluminum housing.

THE Astatic CORPORATION
ASTATIC CONNEAUT, OHIO
IN CANADA: CANADIAN ASTATIC LTD. TORONTO ONTARIO

*Astatic Crystal Devices manufactured under Brush Development Co. patents*

# NEW! STANDARD SIGNAL GENERATOR

MEASUREMENTS Model 82

## 20 CYCLES TO 50 MC. IN ONE INSTRUMENT!

THIS new *Laboratory Standard* is designed for the extremely wide frequency coverage of 20 cycles to 50 megacycles, employing two specially designed oscillators.

A low frequency oscillator, in the range from 20 cycles to 200 kilocycles, provides continuously variable, metered output from 0 to 50 volts across 7500 ohms. This is sufficient for most measurements at audio and supersonic frequencies. It may also be used as the modulator for the radio frequency oscillator.

A radio frequency oscillator covers the range from 80 kilocycles to 50 megacycles. It provides metered output, continuously variable with an improved mutual inductance type attenuator, from 0.1 microvolt to 1 volt. This voltage range makes possible most receiver measurements including the determination of a.v.c. characteristics and interference susceptibility.

### SPECIFICATIONS:

**Frequency Range:** 20 cycles to 50 megacycles. (20 cycles to 200 kilocycles in four ranges; 80 kilocycles to 50 megacycles in seven ranges; plus one blank range.)

**Frequency Calibration:** Direct reading dial, individually-calibrated for each range.

**Frequency Accuracy:** 20 cycles to 200 kilocycles, accurate to ± 5%. 80 kilocycles to 50 megacycles, accurate to ± 1%

**Output Voltage and Impedance:** 0 to 50 volts across 7500 ohms from 20 cycles to 200 kilocycles. 0.1 microvolt to 1 volt across 50 ohms over most of the range from 80 kilocycles to 50 megacycles. (Improved mutual inductance type attenuator.) The output voltage or impedance of either range can be changed by the use of external pads.

**Modulation:** (80 KC—50 MC range) Continuously variable from 0 to 50% from 20 cycles to 20 kilocycles by internal low frequency oscillator or external source.

**Harmonic Output:** Less than 1% from 20 cycles to 20 kilocycles; 3% or less from 20 kilocycles to 50 megacycles.

**Leakage and Stray Field:** Less than 1 microvolt from 80 kilocycles to 50 megacycles.

**Power Supply:** 117 volts, 50 to 60 cycles. 75 watts.

**Dimensions:** 15" high x 19" wide x 12" deep, overall.

**Weight:** 50 lbs.

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY


# MEMBERSHIP

*(Continued from page 37A)*

Hallworth, F. D., Hq. 1932 AACS Sq., APO 677, c/o Postmaster, New York, N. Y.
Hameed, A., c/o Q. A. Hameed, M. S. Fy., Ltd., P.O. Motipur, Dist. Mozaffarpur, (Bihar) India
Haupt, R. H., 4631 N. Wolcott, Chicago 40, Ill.
Hojman, M., Charcas 1391, Buenos Aires, Argentina
Hutchens, S., Jr., 6347 St. Lawrence Ave., Chicago, Ill.
Ingersoll, E. R., 529 E. Fairhaven St., Wilmington, Calif.
Jackson, J., 442 N. 17, St. Joseph, Mo.
Jacobson, M. L., 75 Lenox Rd., Brooklyn 26, N. Y.
Katahara, S., Box 1755 Wailuku, Maui, Hawaii
Kelley, J. R., 1805 Walworth Ave., Pasadena 6, Calif.
Kohler, N. E., Route 1, New Philadelphia, Ohio
Konen, R. W., 212-30 Nashville Blvd., St. Albans, L. I., N. Y.
Kukasch, H. L., 1019 Woodycrest Ave., New York 52, N. Y.
Lathrop, P. A., 3006 Avon Lane, San Pablo, Calif.
Lewis, G. E., 18948 Marlowe Ave., Detroit, Mich.
Lux, K. E., 204 N. 17, St. Joseph, Mo.
Mangru, S. J., 24 Sackville, Trinidad, B.W.I.
Mattingly, C. A., 17 Sibley St., Hammond, Ind.
Mauldin, W. D., 3119 Sixth St., Port Arthur, Tex.
Mayes, W., Jr., 2300 Vine St., Brownwood, Tex.
Michaels, W. H., 41 Ximeno Ave., Long Beach, Calif.
Miller, C. L., Cottage Inn, R.D. 3, Valparaiso, Ind.
Morris, J. C., 1654 State St., New Orleans, La.
Mott, R. H., 301 Sixth, Angola, Ind.
Ozkan, S. H., 84 Neugasse, Zurich 5, Switzerland
Pasqua, L., A.I.L., Inc., 160 Old Country Rd., Mineola, L. I., N. Y.
Perkins, H. T., 412 Briar Pl., Libertyville, Ill.
Rayton, R. C., 12040 75, S., Seattle 88, Wash.
Rozzoni, A. C., 198 Washington Ave., New Rochelle N. Y.
Robbins, J. D., 175 Laurelwood Ct., Emporium, Pa
Sarran, R., 6207 W. Montrose Ave., Chicago 34, Ill
Shuppert, W. G., 548 W. 123 St., Chicago 28, Ill
Stocker, D. O., 3244 S. 13 St., St. Louis 18, Mo.
Stone, R. N., 3060th AMC HQ. Support Sq., W.P.A.F.B., Dayton, Ohio
Subrahmanyan, T. R., 54 Velliambalam St., Madura, S. India
Sutro, L. L., Electrical Engineering Dept., Tufts College, Medford, Mass.
Sykes, J. D., 2086 French, Beccar FENGBM, Buenos Aires, Argentina
Teplitz, W. B., 1687 Commonwealth Ave., Brighton 35, Mass.
Territo, J. N., 1660 W. Ogden Ave., Chicago 12, Ill.
Trimarco, F. J., 850 N. Central Park Ave., Chicago, Ill.
Veronda, C. M., 52 Pond Lane, Hicksville, N. Y.
Vogel, A. P., Jr., 2652 Westfield Ave., Dayton, Ohio
Whitmore, R. C., Rm. 308, Empire Bldg., Syracuse, N. Y.
Wickhem, R. J., 716 Edgewood Ave., Madison 5, Wis.
Wilkin, G. H., 431 Fountain Ave., Dayton 5, Ohio
Winnette, E. A., 118 E. Sixth St., Emporium, Pa.
Witty, H. E., 5339 S. E Malden St., Portland 6, Ore

### Supplementary List—September 1, 1949 elections to Associate

Burgess, C. H., 2491 McFaddin, Beaumont, Tex.
Case, C. C. Jr., 9 Beckett St., Hoosick Falls, N. Y.
Cline, B. V., 1725 Wilson Ave., Chicago 40, Ill.
Eager, G. S., Jr., General Cable Corporation, Bayonne, N. J.

*(Continued on page 39A)*

## MEMBERSHIP

*(Continued from page 38A)*

**The following transfers to the Associate grade were approved to be effective as of August 1, 1949:**

Berkenkamp, F. J., 732 W. Onondaga St., Syracuse, N. Y.
Carrell, R. M., 15 W. Coulter, Collingswood 7, N. J.
Ciletti, V. J., 3407 Hartel Ave., Philadelphia 36, Pa.
Eigner, H., 54 West 175 St., New York 53 N. Y.
Geary, L. W., 5506 Parkland Ct., Washington 19, D. C.
Halijaki C. A., 120 S. Randall Ave., Madison 5, Wis.
Levy, B., 2023 Washington Ave., New York 57, N. Y.
Meyer, R. C., Jr., 9 Curtiss Pl., New Brunswick, N. J.
Meyerson, M., 150 Leslie St., Newark 8, N. J.
Mitchell, C. T., 202 Harrison St., La Porte, Ind.
Roediger, F. E., OTD, The Ordnance School, Aberdeen Proving Ground, Aberdeen, Md.
Salisbury, J. D., 925 W. Seventh, N., Salt Lake City 3, Utah
Sell, R. L., 7233 Vincent Ave., S., Minneapolis 19, Minn.
Stambaugh, D. W., 738 Fifth St., Columbus, Ind
Stonesifer, R. A., 20 Shaffer Ave., Ridgway, Pa.
Strain, D. C., 4635 S.E. Hawthorne, Portland 15, Ore.
Thompson, L. H., 212 Birmingham Ave., Norfolk 5, Va.
Vincent, W. R., c/o Paul Hedtler, Chestnut Ridge Rd., R.F.D., 4, Lockport, N. Y.
Wing, R. Y., 200 Talbot Ave., Santa Rosa, Calif

# News—New Products

**These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.**

*(Continued from page 18A)*

### New Whip-Type Antenna

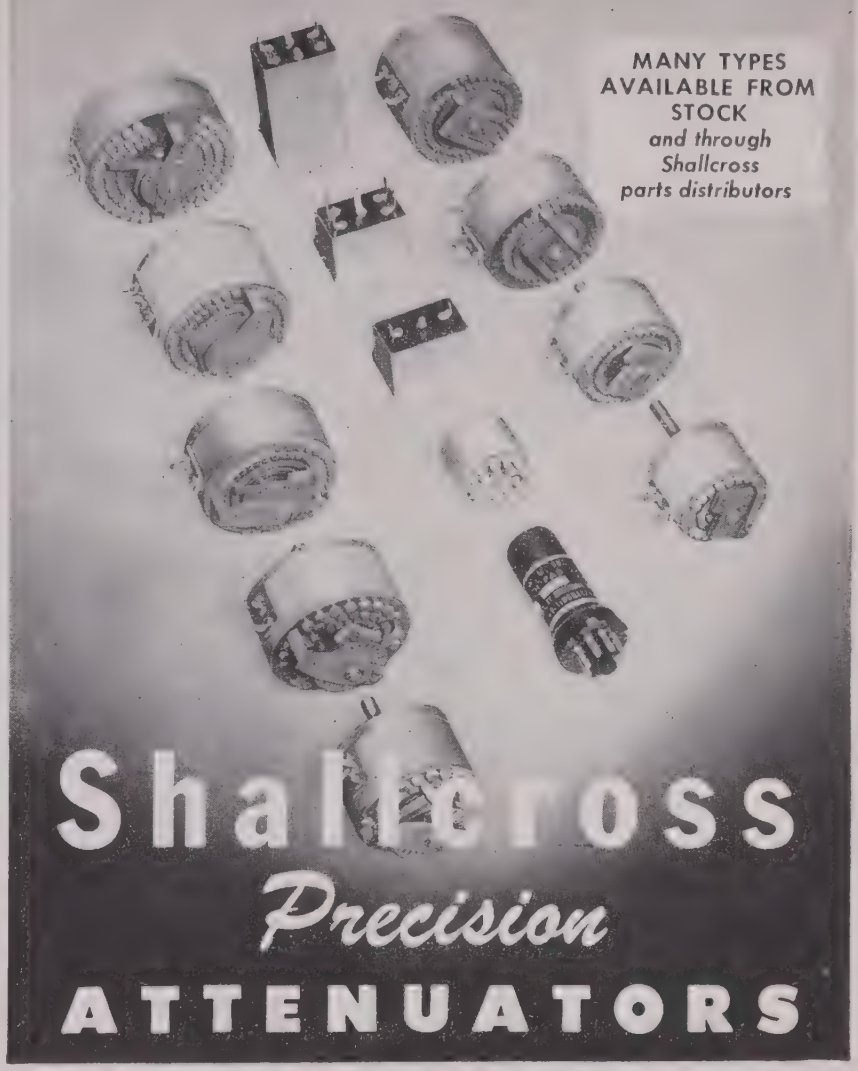
A new mobile antenna to cover the 75-meter band has been introduced by **Premax Products,** Niagara Falls, N. Y.

This design incorporates a special base-loading coil and a graduated or tapering whip of about 6 feet in length, giving a total over-all length of about 88 inches.

It is claimed that this type of antenna shows about a 6-db gain over the conventional "whip" types. Such a gain is of importance to the user as it equals the quadrupling of transmitter power and increases the effectiveness and range of mobile operations, both on transmission and on reception, without involving any great expense for equipment. Reports state the use of this antenna has gone a long way in offsetting many of the difficulties encountered in the 75-meter band.

*(Continued on page 42A)*


*Really Smooth—Outstandingly Quiet—Fully Dependable*




ALL STANDARD FIXED AND VARIABLE TYPES
•
LADDER AND BALANCED LADDER CONTROLS
•
"T" CONTROLS
•
BALANCED "H" CONTROLS
•
POTENTIOMETERS
•
VARIABLE IMPEDANCE MATCHING NETWORKS
•
V.U. METER RANGE EXTENDING ATTENUATORS
•
STANDARD AND SPECIAL FIXED PADS
•
SPECIAL NETWORKS

Perhaps you've noticed how frequently Shallcross attenuators now appear in the finest audio or communications equipment? Or how often they are chosen for replacement purposes?

There's a reason! Improved design, materials and production techniques have resulted in a line that sets new, higher standards of attenuation performance for practically every audio and communications use.

Shallcross Attenuation Engineering Bulletin 4 gladly sent on request.

**Shallcross Manufacturing Co.**
Dept. PR-109 Collingdale, Pa.

**RESISTORS — INSTRUMENTS — SWITCHES — ATTENUATORS**

# R. F. COMPONENTS–MICROWAVE–TEST EQUIPMENT

## 1.25 CENTIMETER

**"K" BAND DIRECTIONAL COUPLER** CU104/APS-34 20 DB ..... $49.50 ea.
**"K" BAND FEEDBACK TO PARABOLA HORN,** with pressurized window ..... $30.00
**MITRED ELBOW** cover to cover ..... $4.00
**TR/ATR SECTION** choke to cover ..... $4.00
**FLEXIBLE SECTION** 1" choke to choke .... $5.00
**ADAPTER,** rd. cover to sq. cover ..... $5.00
**MITRED ELBOW** and S sections choke to cover ..... $4.50
**WAVE GUIDE** ½ x ¼ per ft. ..... $1.00
**K BAND CIRCULAR FLANGES** ..... 50¢
3J31 "K" BAND MAGNETRON ..... $55.00

## 3 CENTIMETER

(STD. 1" x ½" GUIDE UNLESS OTHERWISE SPECIFIED)

**723 A/B Klystron mixer section** with crystal mount, choke flange and Iris flange output ..... $22.50
**TR-ATR Section** for above with 724 ATR Cavity ..... $8.50
**TWIST** 90 deg. 6" long ..... $8.00
**90 degree twist,** 6 inches long ..... $8.00
**723 AB Mixer**—Beacon Dual Oscillator Mount with Crystal holder ..... $12.00
**2 Way Wave directional coupler,** type N fitting 1⅛" x ⅝" giude 26DB ..... $18.50
**CG 98B/APG** 13, 12" flexible section 1¼" x ⅝" OD ..... $10.00
**TR-ATR Section,** APS 15, for 1B24, with 724 ATR Cavity with 1B24 and 724 tubes. Complete ..... $21.00
**Crystal mount** ..... $17.50
**Stabilizer Cavity** with bellows ..... $21.50
**3 cm. 180° bend with pressurizing nipple** ..... $6.00 ea.
**3 cm. 90 bend,** 14" long 90° twist with pressurizing nipple ..... $6.00 ea.
**3 cm.** "S" curve 18" long ..... $5.50 ea.
**3 cm.** "S" curve 6" long ..... $3.50 ea.
**3 cm. right angle bends.** "E" plane 18" long cover to cover ..... $6.50 ea.
**3 cm. Cutler feed dipole.** 11" from parabola mount to feed back ..... $8.50 ea.
**TWIST** 45 deg.. 6" long ..... $8.00
**APS-31 mixer section** for mounting two 2K25's. Beacon reference cavity 1B24 TR tube. New and complete with attenuating slugs $42.50 ea.
**DUPLEXER SECTION** for 1B24 ..... $10.00
**CIRCULAR CHOKE FLANGES,** solid brass .55
**SQ. FLANGES, FLAT BRASS** ..... ea. .55
**APS-10 TR/ATR DUPLEXER** section with additional iris flange ..... $10.00
**FLEX. WAVEGUIDE** ..... $4.00/Ft.
**TRANSITION** 1 x ½ to 1¼ x ⅝, 14 in. .. $8.00
**"X" BAND PREAMPLIFIER,** consisting of 2-723 A/B local oscillator-beacon feeding waveguide and **TR/ATR** Duplexer sect. incl. 30 mc Preamp ..... $67.50
**Random Lengths wavegd,** 6" to 18" Lg. $1.10/Ft.
**WAVEGUIDE RUN.** 1¼" x ½" guide, consisting of 4 ft. section with Rt. angle bend on one end 2" 45 deg. bend other end .... $8.00
**WAVEGUIDE RUN, 1¼" x ½" guide,** 4 ft. long ..... $10.00
**"X" BAND PRESSURIZING** gauge section w/15-lbs. gauge & Pressurizing Nipple $18.50
**45 DEG. TWIST** 6" Long ..... $10.00
**12" SECTION** 45 deg twist, 90 deg bend $6.00
**15 DEG BEND** 10" choke to cover ..... $4.50
**5 FT. SECTIONS choke to cover,** Silver Plated ..... $14.50
**18" FLEXIBLE SECTION** ..... $17.50
**"E" PLANE BENDS** ..... $12.50
**"X" BAND WAVEGUIDE** 1¼" x ⅝" OD 1/16" wall Aluminum ..... Per Foot $ .75
**WAVEGUIDE** 1" x ½" I.D. ..... Per Foot $1.50
**TR CAVITY** For 724 A TR Tube ..... $3.50
**3" FLEX SECT.** sq. flange to Circ. Flange Adapt ..... $7.50
**724 TR TUBE** (41 TR 1) ..... $2.50
**SWR MEAS. SECTION, with 2 type "N"** output probes MTD full wave apart. Bell size guide. Silver plated ..... $10.00
**ROTARY JOINT** with slotted section and type "N" output pickup ..... $17.50
**WAVEGUIDE SECTION,** 12" long choke to cove. 45 deg. twist & 2½" radius, 90 deg. bend ..... $4.50
**SLUG TUNER/ATTENUATOR,** W. E. guide, gold plated ..... $6.50
**TWIST** 90 deg. 5" choke to Cover w/press nipple ..... $6.50
**WAVEGUIDE SECTIONS** 2½ ft: long silver plated with choke flange ..... $5.75
**ROTARY JOINT** choke to choke ..... $17.50
**ROTARY JOINT** choke to choke with deck mounting ..... $17.50
**3 cm. mitred elbow** "E" plane unplated ..... $6.50 ea.

## 10 CENTIMETER

**WAVEGUIDE TO ⅞" RIGID COAX "DOORKNOB" ADAPTER. CHOKE FLANGE. SILVER PLATED BROAD BAND** ..... $32.50
**WAVEGUIDE DIRECTIONAL COUPLER,** 27 db. Navy type CABV-47AAN, with 4 in. slotted section ..... $32.50
**SQ. FLANGE** to rd choke adapter, 18 in. long OA 1½ in. x 3 in. guide, type "N" output and sampling probe ..... $27.50
**Crystal Mixer** with tunable output **TR** pick up loop, Type "N" connectors. Type 62ABH ..... $14.50
**Slotted line probe.** Probe depth adjustable, Sperry connector, type CPR-14AAO .. $9.50
**Coaxial slotted section,** ⅝" rigid coax with carriage and probe ..... $25.00
**Waveguide Transition** from 1½" x 3" to 2" x 1" ..... $45.00
**Right Angle Bend** 6" radius E or H plain $27.50
**Right Angle Bend** 3" radius E or H plain—Circular flanges ..... $17.50
**AN/APR5A** 10 cm antenna equipment consisting of two 10 CM waveguide sections, each polarized. 45 degrees ..... $75.00 per set
**APN-7 McNally Cavity** for 707B, with tuning slugs ..... $5.50 ea.
**VG65/v** ..... $8.50
**VG53/v** ..... $4.00
**PICKUP LOOP,** Type "N" Output ..... $2.75
**TR BOX** Pick-up Loop ..... $1.25
**POWER SPLITTER:** 726 Klystron input dual "N" output ..... $5.00
**MAGNETRON TO WAVEGUIDE** coupler with 721-A duplexer cavity, gold plated .. $27.50
**10 CM WAVEGUIDE SWITCHING UNIT,** switches 1 input to any of 3 outputs. Standard 1½" x 3" guide with square flanges. Complete with 115 vac or dc arranged switching motor. Mfg. Raytheon. CRP 24AAS. New and complete ..... $150.00
**10 CM END-FIRE ARRAY POLYRODS $1.75 ea.**
**"S" BAND** Mixer Assembly, with crystal mount, pick-up loop, tunable output ..... $3.00
**721-A TR CTVITY WITH TUBE.** Complete with tuning plungers ..... $12.50
**10 CM. McNALLY CAVITY** Type SG .... $3.50
**WAVEGUIDE SECTION,** MC 445A, rt. angle bend, 5½" ft. OA. 8" slotted section .. $21.00
**10 CM OSC. PICKUP LOOP,** with male Homedell output ..... $2.00
**10 CM DIPOLE WITH REFLECTOR** in lucite ball, with type "N" or Sperry fitting .. $4.50
**10 CM FEEDBACK DIPOLE ANTENNA,** in lucite ball, for use with parabola ⅞" Rigid Coax Input ..... $8.00
**PHASE SHIFTER.** 10 CM WAVEGUIDE, WE TYPE ES-683816. E PLANE TO H PLANE, MATCHING SLUGS ..... $95.00
**721A TR cavities.** Heavy silver plated $2.00 ea.
**10 cm. horn and rotating** joint assembly, gold plated ..... $65.00 ea.

## ⅞" RIGID COAX—⅜" I.C.

**⅞" rigid coaxial tuning stubs** with vernier stub adjustment. Gold Plated ..... $17.50
**⅞ RIGID COAX ROTARY JOINT.** Pressurized, Sperry #810613. Gold Plated ..... $27.50
Dipole assembly. Part of SCR-584 .... $25.00 ea.
Rotary joint. Part of SCR-584 ..... 35.00 ea.
**RIGHT ANGLE BEND,** with flexible coax output pickup loop ..... $8.00
**SHORT RIGHT ANGLE BEND,** with pressurizing nipple ..... $3.00
**RIGID COAX** to flex coax connector ..... $3.50
**STUB-SUPPORTED RIGID COAX,** gold plated 5' lengths. Per length ..... $5.00
**RT. ANGLES** for above ..... $2.50
**RT. ANGLE BEND 15" L. OA** ..... $3.50
**FLEXIBLE SECTION,** 15" L. Male to female ..... $4.25
**MAGNETRON COUPLINGS** to ⅞" rigid coax. with TR pickup loop, gold plated .... $7.50
**FLEX COAX SECT.** Approx. 30 ft. ..... $16.50
**CG 54/U**—4 foot flexible section ¼" IC pressurized ..... $15.00
⅞ RIGID COAX. Bead Supported ..... $1.20
**SHORT RIGHT ANGLE BEND** ..... $2.50
Rotating joint, with deck mounting .... $15.00
**RIGID COAX** slotted section CU-60/AP .. $5.00

## WAVEGUIDE

| | |
|---|---|
| . x ⅛" ID | $1.00 per foot |
| . x . OD | 1.50 per foot |
| . x 1¼ OD | 1.65 per foot |
| . x 1¼ OD Aluminum | .75 per foot |
| . x 3" OD | 3.00 per foot |
| 2½" x 3" OD | 3.50 per foot |

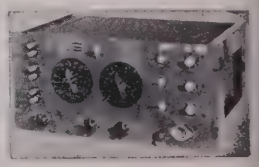
## TEST EQUIPMENT

**TS-117/GP 10 CM WAVEMETER TEST SET,** Mfg. "Sperry" 2400-3400 MC. Micrometer Adj. Coaxial Cavity. Freq. Meas. by absorption or transmission method. Mounts Crystal Current Meter & Calib. Chart ..... $175.00
**VSWR AMPLIFIER TS-12/AP.** Unit 1 3 stages of Amplif. and Diode Rectifier w/direct VSWR. reading on meter. 115 volts 60 cyc. AC operation w/Inst. BK and CCT diag. New ..... $285.00
**SLOTTED LINE PROBE** and Matched Termination including Accessories TS-12/AP Unit 2 incl.
UG81/U, CG92/U, CG91/U, CG89/U, UG79/U, CG87/U, MX158/U, CG88/U, CG90/U, UG80/U plus Tools. New ..... $200.00
**COMPLETE TS-12/AP UNITS 1 AND 2 $450.00**

**MODEL TS-268/U**

**Test set designed to provide a means of rapid checking of crystal diodes IN21, IN21A, IN21B, IN23, IN23A, IN23B. Operates on 1½ volt dry cell battery. 3x6x7.**
New ..... $35.00

**10CM ECHO BOX CABV** 14ABA-1 of OBU-3, 2890 MC to 3170 MCS direct reading micrometer head. Ring prediction scale plus 9% to minus 9%. Type "N" input. Resonance indicator meter. New and Comp. w/access. Box and 10 CM Directional Coupler ..... $350.00
**3 CM RECEIVER.** SO-3. Complete with W.G. Mixer Assy (723-A/B). Reg. Fil. Power Supply 6 stages IF (6AC7) ..... $99.50
**10 cm. horn assembly** consisting of two 5" dishes with dipoles feeding single type "N" output. Includes UG28/U type "N" "T" junction and type "N" pickup probe. Mfg. cable. New ..... $5.56 ea.
**10 cm. cavity** type wavemeters 6" deep, 6½" in diameter. Coax. output. Silver plated ..... $64.50 ea.
**10 cm. ECHO BOX:** Part of SF-1 Radar, W/115v D.C. Tuning motor sub sig 118A .. $47.50 ea.
**THERMISTOR BRIDGE:** Power meter 1-203-A. 10 cm. mfg. W.E. Complete with meter, interpolation chart, portable carrying case ..... $72.50
**W.E. 1 138.** Signal generator. 2700 to 2900 Mc. range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input reg. Pwr. supply. With circuit diagram .... $75.00
3 cm. Wavemeter: 9200 to 11,000 mc. transmission type with square flanges ..... $15.00
3 cm. stabilizer cavity, transmission type $20.00
**TS 89/AP VOLTAGE DIVIDER**—New .... $42.50
**TS-108A/P DUMMY LOAD** ..... $65.00
**3 CM. HORN AT-48/UP** model 710. Type "N" input Hvy. silver plated ..... $6.50
**AT-68/UP** 3 CM Horn with type N fitting .$5.00



**MODULATOR UNIT BC 1203-B** Provides 200-4,000 PPS. Sweeptime 100 to 2,500 microsec. in 4 steps fixed mod. pulse, suppression pulse, sliding modulating pulse, blanking voltage, marker pulse, sweep voltages, calibration voltages, fil. voltages. Operates 115 vac. 50-60 cy. Provides various types of voltage pulse outputs for the modulation of a signal generator such as General Radio #804B or #804C used in depot bench testing of SCR 695, SCR 595, and SCR 535. New as shown ..... $125.00

| THERMISTORS | | VARISTORS | |
|---|---|---|---|
| D-167332 (tube) | $.95 | D-170225 | $1.25 |
| D-170396 (bead) | $.95 | D-167176 | $.95 |
| D-167613 (button) | $.95 | D-168687 | $.95 |
| D-166228 (button) | $.95 | D-171812 | $.95 |
| D-164699 for MTG, in "X" band Guide | $2.50 | D-171528 | $.95 |
| | | D-168549 | $.95 |
| D-167018 (tube) | $.95 | D-162482 | $3.60 |
| D-171121 | $.95 | D-163298 | $1.25 |
| 3A(12-43) | $1.50 | D-99428 | $2.00 |
| D-167020 | $3.00 | D-161871A | $2.85 |

ALL MERCHANDISE GUARANTEED. MAIL ORDERS PROMPTLY FILLED. ALL PRICES F.O.B. NEW YORK CITY. SEND MONEY ORDER OR CHECK ONLY. SHIPPING CHARGES SENT C.O.D. RATED CONCERNS SEND P. O. MERCHANDISE SUBJECT TO PRIOR SALE

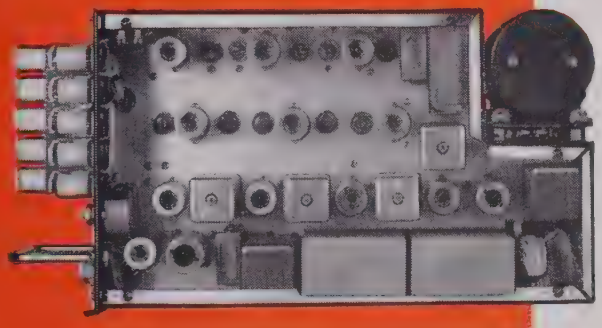
**COMMUNICATIONS EQUIPMENT CO.**
131 "I 10" Liberty St., New York, N.Y. Cable "Comsupo" Ph. Digby 9-4124

51V-1 glideslope receiver, covers in place

# Glideslope Receiver

## 51V-1

## . . . inside and out



Collins 51V-1 chassis (right side)

Collins 51V-1 chassis (left side)

THIS is the new Collins 51V-1 glideslope receiver for aircraft. Note the orderly design, and the accessibility of all tubes, components, and wiring.

The 51V-1 provides reception of 90/150 cps tone modulated glideslope signals on any of the twenty channels in the uhf range of 329-335 mc. This receiver together with Collins 51R navigation equipment will fulfill ILS receiving requirements for military, commercial and private aircraft. The design of the 51V-1 is based on "Glideslope Receiver Characteristics" issued by Aeronautical Radio, Inc., and on U. S. Airforce specifications.

Output circuits of the 51V-1 receiver feed standard ID-48ARN deviation indicators including flag alarm. By means of the flag alarm the pilot has a positive indication of the reliability of the glideslope signals and instrumentation.

The 51V-1 control circuits are integrated with the standardized R/θ channeling system with channel selection provided by means of a Collins 314U remote control unit.

More complete information, in the form of an illustrated bulletin, is yours on request.

IN AVIATION RADIO, IT'S...

COLLINS

**COLLINS RADIO COMPANY, Cedar Rapids, Iowa**

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NEW YORK 18

2700 West Olive Ave.
BURBANK

M & W Tower
DALLAS 1

Fountain City Bank Bldg.
KNOXVILLE

AIRCRAFT
RADIO
CORPORATION

Type H-12
SIGNAL GENERATOR
900-2100 MEGACYCLES

–Simplified
–Compact
–Portable

- 900-2100 megacycles, single band
- Directly calibrated, single dial frequency control
- Directly calibrated attenuator, 0 to –120 dbm
- CW or AM pulse modulation
- Internal pulse generator with controls for width, delay, and rate. Provision for external pulsing
- Controls planned and grouped for ease of operation
- Weight: 42 lbs. Easily portable—ideal for airborne installations
- Immediate delivery

*Built to Navy Specifications for research and production testing*

*Write for specifications — investigate the advantages of this outstanding new instrument.*

DEPENDABLE ELECTRONIC EQUIPMENT SINCE 1928

Aircraft Radio Corporation
BOONTON, New Jersey

## SECTION MEETINGS

### Buenos Aires

"Section's Activity for 1948," by G. E. Van Spankeren, Chairman, and C. N. Cutler, Secretary-Treasurer; April 8, 1949.

"Ionospheric Propagation," by J. M. Onativia, Faculty of Ciencias Fisicas y Matematicas de Buenos Aires; April 22, 1949.

"Ultra-High Frequency Mobile Radiotelegraph Systems," by J. L. Coriat, Compania Standard Electric Argentina S.A.; June 13, 1949.

"New Procedure of Tube Manufacture," by J. M. Jadraque, Philips Argentina S.A.; July 1, 1949.

"Modern Systems on Single Side Band," by Adolfo Di Marco, Philips Argentina S.A.; July 15, 1949.

"Frequency Shift Keying System," by C. P. Perez, Standard Electric Argentina S.A.; August 5, 1949.

"Design of Broadcasting Studios," by L. L. Beranek, Vice-President, Acoustical Society of America; August 19, 1949.

### Chicago

"Electrical Computers and Alternatives in Strategy," by C. E. Shannon, Bell Telephone Laboratories; and Election of Officers; May 13, 1949.

### Dallas-Fort Worth

"Anechoic Chamber," by H. W. Rudmose, Faculty of Southern Methodist University; August 25, 1949.

### Dayton

"Design Trends in Home Television Receivers," by J. D. Reid, Crosley Division AVCO Manufacturing Company; September 8, 1949.

### Denver

"Experimental Television Camera Chain," by C. M. Eining, A. C. McClellan, W. S. Neal, Jr., and K. N. Raymond, Video Associates of Denver; September 9, 1949.

### Inyokern

"Recent High Power Microwave Developments at the University of California," by L. C. Marshall, Faculty of University of California; June 28, 1949.

### Kansas City

Student Paper Competition; April 26, 1949.

### Los Angeles

"History and Objectives of United States Naval Ordnance Test Station," by B. E. Lawrence, U.S.N.O.T.S. "General Instrumentation at United States Naval Ordnance Test Station," by E. R. Toporeck, U.S.N.O.T.S.; September 6, 1949.

### New Mexico

"Electronics in Measurement and Control," by R. H. Mueller; August 19, 1949.

### Pittsburgh

"Recent Trends in High-Fidelity Reproduction," by C. T. Hall, Hall Radio Laboratories; September 12, 1949.

### Portland

"Electronics in Paper Making," by J. F. Kovalsky, Westinghouse Electric Corporation; June 10, 1949.

"Contact Potentials of Tubes Operated at Low Potentials," by G. D. O'Neill, Sylvania Electric Products Company; September 6, 1949.

"Recent Actions of Federal Communications Commission in Television," by President S. L. Bailey, The Institute of Radio Engineers; August 29, 1949.

*(Continued on page 40A)*

*Station WICA, Ashtabula, Ohio*

THE consulting radio engineer prescribed uniform cross section towers of maximum strength and efficiency for this directional array, but the budget demanded a minimum of expenditure. So there was only one place to take the prescription—BLAW-KNOX.

The three type LT towers illustrated, although low in cost, have the strength and high factor of safety characteristic of Blaw-Knox design and engineering. The type SGN tower completing the array has the additional strength to support the heavy-duty FM pylon and any future TV requirements.

Your tower prescription will be promptly filled at BLAW-KNOX.

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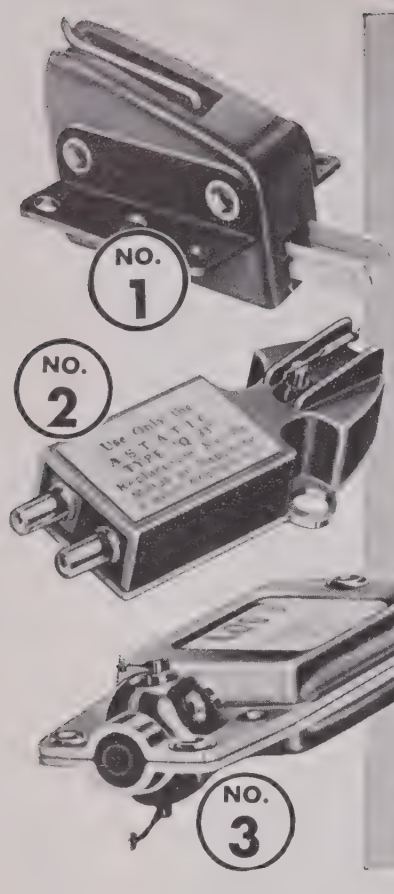
OFFICES IN 100 PRINCIPAL CITIES

**BLAW-KNOX DIVISION** OF BLAW-KNOX COMPANY
2037 FARMERS BANK BUILDING, PITTSBURGH 22, PA.

# BLAW-KNOX ANTENNA TOWERS




THESE THREE
NEW DEVELOPMENTS
ARE
*Keeping*
ASTATIC
*Out in Front*
IN THE
MANUFACTURE OF
PICKUP
CARTRIDGES

## 1 GC CERAMIC CARTRIDGE

First major engineering stride in phonograph pickup cartridges employing ceramic elements since Astatic pioneered in this type unit last year. The GC is the first cartridge of its kind with replaceable needle. Takes the special new Astatic "Type G" needle—with either one or three-mil tip radius, precious metal or sapphire—which slips from its rubber chuck with a quarter turn sideways. Resistance of the ceramic element to high temperatures and humidity is not the only additional advantage of this new development. Output has been increased over that of any ceramic cartridge available. Its light weight and low minimum needle pressure make it ideal for a great variety of modern applications.

## 2 CQ CRYSTAL CARTRIDGE

An entirely new Astatic design, featuring miniature size and five-gram weight. Model CQ-J fits standard 1/2" mounting and RCA 45 RPM record changers. Model CQ-1J fits RMA No. 2 Specifications for top mounting .453" mounting centers. Needle pressure five grams. Output 0.7 volts at 1,000 c.p.s. Employs one-mil tip radius, Q-33 needle. Cast aluminum housing.

## 3 LQD Double-Needle Crystal Cartridge

The LQD Cartridge—for 45, 33-1/3 and 78 RPM Records—quickly became the first choice of many of the nation's largest users, on the basis of comparative listening tests, and is, today, the PROVED TOP PERFORMER for turnover type pickups. Outstanding for excellence of frequency response, particularly at low frequencies. A gentle pry with penknife removes ONE needle for replacement . . . without disturbing the other needle, without removing cartridge from tone arm. Gentle pressure snaps new needle into place. Available with or without needle guards. Stamped aluminum housing.

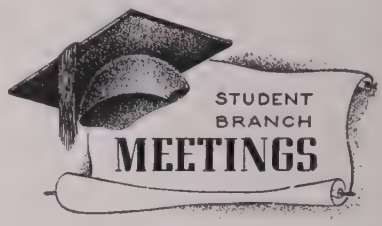
THE Astatic CORPORATION
ASTATIC
CONNEAUT, OHIO
IN CANADA: CANADIAN ASTATIC LTD. TORONTO, ONTARIO

Astatic Crystal Devices manufactured under Brush Development Co. patents

*(Continued from page 38A)*

WASHINGTON

"Television Broadcast Antennas Having Higher Gains and Directive Patterns," by L. J. Wolf, RCA Victor Division; and "Low Cost Television Stations," by Walter Lawrence, RCA Victor Division; September 12, 1949.




UNIVERSITY OF LOUISVILLE—IRE BRANCH

Business Meeting; August 25, 1949.

POLYTECHNIC INSTITUTE OF BROOKLYN—IRE BRANCH

"Impedance Measurements at Microwave Frequencies," by Frank Klawsnik, Sperry Gyroscope Company; December 16, 1948.

Professional Discussion by David Vitrogen, Faculty of Polytechnic Institute of Brooklyn; H. R. Brownell, Consulting Engineer; and Robert Eiermann, Branch Chairman; April 7, 1949.

"The Design of Special Filters," by A. Boggs. Western Union Telegraph Company; April 28. 1949.

"Humanities and the Engineer," by R. H. Robbins, Faculty of Polytechnic Institute of Brooklyn-May 12. 1949.

**The following transfers and admissions were approved, and will be effective as of November 1, 1949:**

### Transfer to Senior Member

Boyd, J. C., 9 N. Front, Clearfield, Pa.
Cruickshank, J. E., 218 East Ave., Valley Stream, L. I., N. Y.
Eberhard, E., 232 Ardmore Ave., Haddonfield, N. J.
Goldsmith, B. M., 7 Lenox Terr., South Orange, N. J.
Hager, F. M., Jr., 711 N. State St., Waseca, Minn.
Hartley, H. F., Jr., 407 Drayton Rd., Oreland, Pa
Hegar, E. A., 802 Telephone Bldg., Dallas 2, Tex.
Johnson, R. W., 303B Langley, U. S. Naval Ordnance Test Station, China Lake, Calif.
Klinestiver, G. H., 356 E. Fifth St., Emporium, Pa.
McGregor, J. C., 69-05A—186 Lane, Flushing, L. I., N. Y.
McLean, T., Forest Dr., Ithaca, N. Y.
Ordung, P. F., Dunham Laboratory, Yale University, New Haven, Conn.
Phatak, R. K., 169 Vincent Rd., Bombay 14, India
Seelen, H. R., RCA, Lancaster, Pa.
Trainer, M. A., Bldg. 15-6, RCA Victor Division Front & Cooper Sts. Camden, N. J.
Weller, D. A., Radio Station WISN, 123 W. Michigan St., Milwaukee, Wis.

### Admission to Senior Member

Coover, M. S., Electrical Engineering Department, Iowa State College, Ames, Iowa

*(Continued on page 44A)*

# Let MARION help you . . .

. . . seal components *hermetically*

. . . speed up sub-assemblies

## Marion portable, bench-type induction soldering unit . . . .

- SMALL
- COMPACT
- ADAPTABLE
- EFFICIENT
- ECONOMICAL
- EASY-TO-USE

**A PRODUCTION TOOL** This unit was designed to simplify and improve both the quality and quantity of production of many different assemblies in the electronic and electrical fields. It has been used successfully for many years in the manufacture of Marion hermetically sealed instruments. Assembly applications include magnet assemblies, relay armatures, connectors, capacitors and transformer cans and germanium diode assemblies; also jewelry, watches, toys, automotive parts, household fixtures, etc.

**HERMETICALLY SEALED COMPONENTS** Because of the present intense interest in hermetically sealed components, Marion offers the benefit of its experience in true glass-to-metal hermetic sealing with the Marion Induction Soldering Unit and Marion metalized (platinum film) glass. Marion platinum film base glass has been developed to permit higher sealing temperatures, greater thermal shock range and resoldering if necessary.

**PROFIT FROM EXPERIENCE** Investigate now. Submit your requirements. We will be glad to supply samples and quotations. Ask for bulletin.

**MANUFACTURERS OF HERMETICALLY SEALED METERS SINCE 1944**

M·E·I

**MARION ELECTRICAL INSTRUMENT COMPANY**

MANCHESTER, NEW HAMPSHIRE

Export Division, 458 Broadway, New York 13, U. S. A., Cables MORHANEX

IN CANADA: THE ASTRAL ELECTRIC COMPANY, SCARBORO BLUFFS, ONTARIO

# Specify CP TEF-LINE SUPER TRANSMISSION LINE

## A new transmission line based upon a new plastic—TEFLON

CP TEF-LINE transmission line, utilizing DuPont Teflon insulators, greatly reduces high frequency power losses. Furthermore, operation of transmission line at frequencies heretofore impossible owing to excessive power loss now becomes easily possible. For TV, FM and other services utilizing increasingly high frequencies, TEF-LINE by CP is a timely and valuable development worthy of investigation by every user of transmission line.

### CP SUPER TEF-LINE IS AVAILABLE NOW!

Tef-Line can be delivered immediately in three standard sizes—7/8", 1 5/8" and 3 1/8". With the exception of elbows and gas stops, the new Seal-O-Flange Super Transmission Line is interchangeable with all other CP fittings including end seals, tower hardware, flanges, "O" rings, inner conductor connectors and miscellaneous accessories.

Check your transmission line requirements with the new CP TEF-LINE BULLETIN which is available on request. If you need help in planning installations, our engineers will be happy to talk over specific problems at your convenience.

• TOWER HARDWARE • AUTO-DRYAIRE DEHYDRATORS
• LO-LOSS SWITCHES • COAXIAL DIPOLE ANTENNAS
• SEAL-O-FLANGE TRANSMISSION LINE

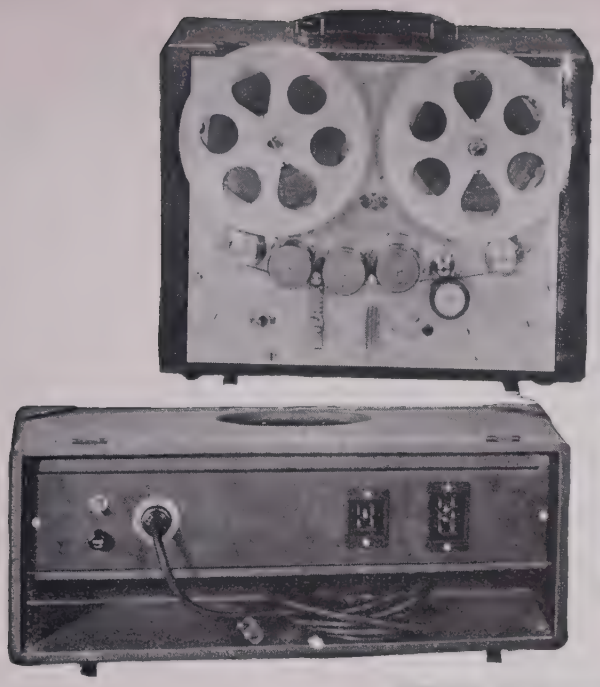
Communication Products Company, Inc.
KEYPORT CP NEW JERSEY


## MEMBERSHIP

(Continued from page 44A)

Bolton, B. A., 2901 Elm St. Denver 7, Colo.
Boulet, L. A., 14495 Rochelle, Detroit 5, Mich.
Brickley, S. F., 83 Walk Hill St., Jamaica Plain, Mass.
Brode, R. L., Box 32, Phoneton, Ohio
Brooks, W. O., 2105 Alma St., San Pedro, Calif.
Brunner, F., Sloane House 356 W. 34 St., New York, N. Y.
Bryan, J. F., Box 160, R.D. 1, Long Branch, N. J.
Bugg, R. W., Airway Communication Station, CAA Box 165, Calumet, Mich.
Casselberry, R. L., General Electric Company, 3037 Book Bldg., Detroit, Mich.
Carpenter, R. E., 506 Adams St., N. Abington, Mass.
Clark, R. M., Box 265A, Route 5, St. Joseph, Mo.
Cooper, P. V., 3965 S. Harvard Blvd., Los Angeles, Calif.
Cother, R. H., 15222 S. Atkinson Ave., Gardena, Calif.
Cox, F., Box 741, Macon, Ga.
Cullen, A. E., Jr., 55 Campbell St., Woburn, Mass.
Dean, A. J., 1500 Bergen Blvd., Fort Lee, N. J.
Delano, H. C., 400 E. Donovan Rd., Kansas City, Kans.
Dowd, F. W., 1122 N. Ninth St., St. Joseph, Mo.
Dressel, H. O., 2459 Glebe Ave., New York 61, N. Y.
Eells, W. A., 1207 Gilham, Philadelphia 11, Pa.
Enyard, H. C., 83 Allerton Rd., Newton Centre 59, Mass.
Erdle, P. J., Sylvania Electric Products, Inc., Emporium, Pa.
Featherston, J. R., 205 N Cuyler Ave., Oak Park, Ill.
Filko, P. P., R. D. 2, Box 399, Cuyahoga Falls, Ohio
Fratkin, B., 309½ Flora Ave., Winnipeg, Man., Canada
Goldbaum, S., 1802 Ocean Pkwy., Brooklyn 23, N. Y.
Gregory B. J., 889 Jessie Ave., Winnipeg, Man. Canada
Guimaraes, B. Q., Rue Sampaio Viana No. 391, Sao Paulo, Brazil
Hanner, J B., Research Laboratories, Swift and Company, Chicago 9, Ill.
Harp, M. C., 214 Beverly Ave., Millbrae, Calif.
Hellmann, R. G., 2108 Ryer Ave. New York 57, N. Y.
Horna, O. A., Praha XIX, Czechoslovakia
Horsman, J O., 3331 Dumaine St., New Orleans 19, La.
Hoskins, J. W., 1439 Ohio St., Vallejo, Calif.
Huskey, H. D., 2237 Manning Ave., Los Angeles 25, Calif
Jaehnig, R. H., 3215 N. 23 St., Milwaukee 6, Wis.
Jeffers, G. W., 28 Upper Ave., Dayton 7, Ohio
Kesgen, E. W., 286 Grove St., E. Rutherford, N. J.
Kelly, J. P., 92 Upland Ave., Newton Highlands 61, Mass.
Kolberg, E. G., 5700 W. Erie, Chicago 44, Ill.
Lannan, W E., 44 Warren Ave., Woburn, Mass.
Maguire, L. R., 221½ E. Sixth St., Emporium, Pa.
Mayle, L. F., Capehart-Farnsworth Corporation, Fort Wayne, Ind.
McCarthy, H. J., 3537 W. 60 St., Chicago 29, Ill.
Ming, D. L., 2111 Pentland St., Temple City, Calif
Mitchell, D. J., 14 Davison St., Hyde Park 36, Mass.
Moore, J M., 1130—18 St., Manhattan Beach, Calif.
Mueller, P. J. 6085 S. 108 St., Hales Corners, Wis.
Noble, W. E., Box 1604, Ktchikan, Alaska
Novello, E. N., 1664—65 St., Brooklyn 19, N. Y.
Nunan, K. W., Sr., R.D. 4, Central St., Georgetown, Mass.
Overholser, W. E., 33 N. Alder Ave., Dayton, Ohio
Papazian, M. G., 2108 Smith St., Fort Wayne 5, Ind.

(Continued on page 48A)



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## indicate this is the world's finest recorder of its type

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## Portable Tape Recorder PT-900

Complete in two easily portable cases—one containing the recorder, the other the amplifying equipment.

**MANY OUTSTANDING FEATURES:**

- Three separate heads for superior performance (and for monitoring direct from tape). One head each to erase, record and play back.
- 3 microphone channels with master gain control in recording amplifier.
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Don't choose your tape recorder until you see the *new* Presto Portable Tape Recorder. Write for complete details today.

Write today to be put on our mailing list for "The Presto Recorder," new house organ of practical ideas for anyone in the recording and broadcasting field.

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*WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT AND DISCS*

*Announcing*

# "Prodelin"

HIGH EFFICIENCY TRANSMISSION LINE

JOB PACKAGED ENGINEERING

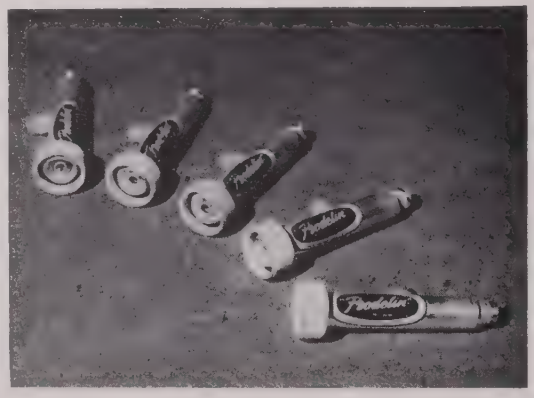
*THROUGH THE MICROWAVE SPECTRUM*

Complete with all necessary system components and designed for optimum performance ready to serve the most critical type service. Pre-installation system testing at our plant or in the field optional at additional cost.

"PRODELIN"* END SEALS

51.5-ohm end seals with our standard "Prodelin" coupling and 1/8" ips. pipe fitting, adapts Prodelin 7/8" line to RG-8/u cable.

Measured VSWR @ 2000mcs. less than 1.1 with end seals terminating 200 ft. of line.



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- Unique insulator design*
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- Exceeds requirements of commercial specifications

**"Prodelin" 51.5-ohm transmission lines, fittings, and tower accessories available in 7/8", 1-5/8", 3-1/8" and 6-1/8" sizes.**

For additional information write for bulletin #1049.

Remember "Prodelin" for

- Rigid and semi-rigid coaxial line for high and low frequency application with low VSWR.
- Solid dielectric flexible coaxial cable and connector assemblies for feeding high and low frequency systems under normal temperatures or for extremely high or low temperature operating requirements.

* U.S. Patent 2,436,284 Feb. 17, 1948.

* Reg. Trade Mark.

**PRODUCT DEVELOPMENT CO., INC.**

ARLINGTON, NEW JERSEY


## MEMBERSHIP

*(Continued from page 46A)*

Patterson, K. P., 842 Fulton St., San Francisco 17, Calif.
Pease, C. H., 20-42 Crescent St., Long Island City 5 N. Y
Perry, J. T., 2917 The Mall, Los Angeles 23, Calif.
Poe, C. M., 2661 Jonguil Dr., San Diego 6, Calif.
Raupp, R. A., Box 151, Gurnee, Ill.
Rimsky, E., 1952 N. Madison Ave., Pasadena 6, Calif.
Roberts, J. V., 37 Burlington St., Ashton-Under-Lyne, Lancs., England
Rogers, A. L., 827 Roswell Ave., Kansas City, Kans.
Rogers, D.C., CAA, Section 67, Box 440, Anchorage, Alaska
Ross, J. D., 8 Oaker Ave., Manchester 20, England
Shaw, H. W., 1644 Baltimore Ave., Kansas City 8, Mo.
Siefken, R. M., 104 Buckworth Dr., Kokomo, Ind.
Siekanowicz, W. W., 105 Audubon Ave., New York, 32, N. Y.
Smith, M. H., 3731 W. 59 Pl., Los Angeles 43, Calif.
Sola, M. C., B. Mitre 366, Argentina
Sulkoski, W. M., 334 Bridle Path. Worcester 4, Mass.
Sundt, E. V., Littelfuse, Inc., 4757 N. Ravenwood Ave., Chicago 40, Ill.
Talmadge, G. E., Electronics Officer, Naval Air Station, Atlanta, Ga.
Toth, W., 4525 N. Clifton Ave., Chicago 40, Ill.
Tutty, J. E., 286 Summer Ave., Newark 4, N. J.
Wehrlin, R. F., 121 E. 24 St., New York 10, N. Y.
White, S. B., 615 Monteray Ave., Dayton 9, Ohio
Whitten, G. A., Box 115, Fort Wayne, Ind.
Wild, A. F., General Electric Company, 140 Federal St., Boston, Mass.
Wirth, S. R., 10835 Farragut Dr., Culver City, Calif
Wojcik, J. J., 7338 Rugby St., Philadelphia 19, Pa.
Zerkin, M., 808A Bergen St., Brooklyn, N. Y.

**The following transfers to the Associate grade were approved to be effective as of September 1, 1949:**

Aldrich, D. H., 1101 Ware Ct., Willow Village, Mich.
Bell, N. W., 60 Oakridge Ave., Summit, N. J.
Bernstein, M. I., 200 Queen St., Kingston, Ont., Canada
Bertran, L. L., 77 Branch Ave., Red Bank, N. J.
Betz, E. S., 418 Nelson Ave., Cliffside Park, N. J.
Curren, W. T., 364 Lewis St., Ottawa, Ont., Canada
Deitzler, R. P., 105 Church St., North Syracuse, N. Y.
Green, E. D., 3112 Chesley Ave., Baltimore 14, Md.
Greenquist, R. E., 3804 Bailey Ave., New York 63, N. Y.
Horner, R. G, 1895 Grand Concourse, New York 53, N.Y
Johnson, R. D., 1507 Elmhurst Dr., N.E., Cedar Rapids, Iowa
Judkins, J. R., 608 Waldron St., West Lafayette, Ind.
Kitchens, J., 745 Pomona Ave., El Cerrito, Calif.
Neuman, I., 120 East 11 St., New York 3, N. Y.
New, R. F., 88 Crosby St., Hornell, N. Y.
Norris, R. M., 1323 Fern Ave., Torrance, Calif.
O'Hearon, J. B., Box 1594, R.D. 2, Auburn, Wash.
Owens, H. A., Jr., Box 2091, University Station, Gainesville, Fla.
Ripnitz, A., 121 Willow Ave., Takoma Park, Md.
Rogers, J. A., 327 Fern St., Little Rock, Ark.
Ryan, R. D., 83 Cottenham Ave., Kingsford, Sydney, N.S.W., Australia
Schwartz, R. G., 2107 St. Paul St., Baltimore, Md.
Spencer, D. L., 417 N. Simpson St., Philadelphia 31, Pa.
Urkowitz, H., 5017 N. Fifth St., Philadelphia 20, Pa.
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# "326" MONEL

non-magnetic
rustless
strong

If metal specification is your responsibility, "*326*"* *Monel* is a name to remember.

In particular, it will pay you to remember the *special* properties of "326" Monel.

"326" Monel is substantially *non-magnetic* at and above room temperatures. The approximate permeability at 68° F. is 1.025 and at 14° F. is 1.1. Neither hot nor cold working appreciably affect its magnetic properties.

"326" Monel is *rust-proof* and highly resistant to most commonly-encountered corrosives.

"326" Monel possesses high physical properties similar to those of Monel—strength, toughness, and resistance to abrasion.

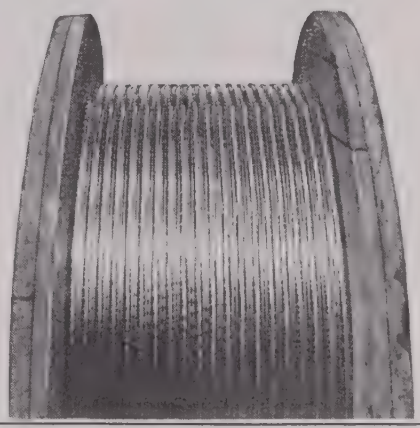
In addition to these valuable physical characteristics, "326" Monel is a thoroughly *practical* metal . . . economical to buy; easy to use; readily workable.

"326" Monel can be welded, brazed, or soldered . . . can be readily machined, formed, drawn, or forged. It is available in standard mill forms.

Next time you are faced with a problem that demands a tough, non-magnetic, corrosion-resistant alloy . . . specify "326" Monel.

Meanwhile, write for your copy of "*Inco Nickel Alloys for Electronic Uses.*" This valuable 26-page booklet gives the composition, characteristics, and typical applications of 18 helpful Inco Nickel Alloys.

*Reg. U. S. Pat. Off.



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Structural parts of special vacuum tubes
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Mill forms including:
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Strip and ribbon, cold-rolled
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**"326" Monel**
Limiting Composition %

| | |
|---|---|
| Ni (+ Co) | 58-61 |
| Cu | remainder |
| Fe | 2.50 max. |
| Mn | 2.00 max. |
| C | .30 max. |
| Si | .50 max. |
| S | .02 max. |

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*Astatic*
MODEL
JL-10

THE JL-10 PICKUP is a new Astatic achievement in tone arms for 78 RPM record reproduction — it's a new accomplishment in quality construction at a cost heretofore associated with vastly inferior equipment. The JL-10 has a rugged, drawn steel arm, modernly attractive in curved design with decorative ribs. Its styling and dark brown Hammerlin finish will make it a harmonious part of any phonograph. The L-10 Crystal Cartridge is specially designed for this tone arm and is available only in this combination. It provides high output of approximately 4.0 volts, ample for use with one-tube amplifiers. The response is ideal for general 78 RPM record reproduction. Needle pressure of 1½ oz. assures long record life. You will want the complete specifications and prices on this bright new Astatic Pickup for your records.

*Astatic Crystal Devices manufactured under Brush Development Co. patents*

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## SECTION MEETINGS

AKRON

"Television Pickup Tubes," by R. B. Janes, Radio Corporation of America; and Business Meeting; September 29, 1949.

BALTIMORE

"Speeding up the Determination of Dielectric Properties of Radio Frequencies," by C. F. Miller, Faculty of Johns Hopkins University; and Business Meeting; October 12, 1949.

BEAUMONT-PORT ARTHUR

"Fundamental Particles of Modern Physics," by J. S. Ham, Jr., Graduate Student, University of Chicago; September 20, 1949.

BUFFALO-NIAGARA

"Summary of Proposed Color Television Systems," by M. G. Nicholson, Colonial Radio Corporation; September 19, 1949.

CLEVELAND

"High-Gain and Directional Antennas for Television Broadcasting," by L. J. Wolf, Engineering Products Division, RCA Victor Division; September 22, 1949.

"Performance of Broadcast Directional Antenna Systems," by J. S. Brown, Chief Engineer, Andrew Corporation; October 18, 1949.

COLUMBUS

"Electronic Arithmetic," by C. N. Hoylar, Radio Corporation of America; September 29, 1949.

CONNECTICUT VALLEY

"Television Station Installation Problems," by Garo Ray, Radio Station WNHC; September 15, 1949.

DALLAS-FT. WORTH

"Inspection Trip of Transmitting Facilities of KRLD-TV," by J. F. Kluttz and Roy Flynn, Radio Station KRLD; October 6, 1949.

DAYTON

"High Permeability Materials," by T. D. Yensen, Westinghouse Electric Corporation; October 26, 1949.

"History of Mathematics and the Digital Computer," by Gunter Nelson and E. V. Gulden, National Cash Register Company; November 10, 1949.

FORT WAYNE

"Design of Electronics Equipment Using Subminiature Components," by M. L. Miller, Capehart Farnsworth Company, October 10, 1949.

HOUSTON

"Some Recent Developments in Electronic Applications to Geophysics," by Eugene Frowe, Robert H. Ray Company; September 27, 1949.

INYOKERN

"Magnetic Recording," by M. J. Stolaroff, Ampex Electric Corporation; and Business Meeting; September 27, 1949.

LONDON

"The Traveling-Wave Tube as a Microwave Amplifier," by R. C. Dearle, Head of Physics Department, University of Western Ontario; October 3, 1949.

NEW MEXICO

"The Effect of Contact Potential Difference in Electron Tube Characteristics," by G. D. O'Neill, Sylvania Electric Products Inc.; September 16, 1949.

*(Continued on page 39A)*

## SECTION MEETINGS

*(Continued from page 34A)*

NEW YORK

"Trends in Air Navigation Instrumentation," by Harry Davis, Watson Laboratories, and George Comstock, Airborne Instrument Laboratories; September 14, 1949.

"Scientific Calculation by Electronic Means," by W. J. Eckert, Watson Computing Laboratory, Columbia University; October 5, 1949.

NORTH CAROLINA-VIRGINIA

"Design Problems of Triodes and Tetrodes for High-Frequency Operation," by C. M. Smith; Machlett Laboratories; September 23, 1949.

PHILADELPHIA

"Visual Sensitivity—How it is Influenced by Ultra-Violet," by Ernst Wolf, American Optical Company; October 6, 1949.

PITTSBURGH

"The X-Ray Image Amplifier Tube," by F. Marshall, Westinghouse Research Laboratories; October 8, 1949.

PORTLAND

"The Measurement of Nonlinear Distortion," by A. P. G. Peterson, General Radio Company; September 8, 1949.

"Antenna Impedance," by F. E. Miller, Pacific Telephone and Telegraph Company; September 22, 1949.

PRINCETON

"Television by Pulse Code Modulation," by W. M. Goodall, Bell Telephone Laboratories; October 13, 1949.

ROCHESTER

"High-Speed Movies with Grid Photography," by W. C. Newcomb, Eastman Kodak Company; October 6, 1949.

SACRAMENTO

"Latest Developments in Color Television," by N. D. Webster, McClatchy Broadcasting System; "Radio Range Facilities," by A. H. Rhode, United States Air Force, McClellan Field; "Direction Finding Facilities," by I. L. Dutton, United States Air Force, McClellan Field; "United States Air Force Television," by Raymond Fisher, United States Air Force, McClellan Field; and "New Developments in Ground Control Approach," by L. A. Querolo, United States Air Force, McClellan Field; September 13, 1949.

SAINT LOUIS

"Universal Phonograph Styli," by J. D. Reid, Crosley Division, AVCO Manufacturing Corporation; September 21, 1949.

SALT LAKE

"Microwaves for Instrument Landing of Aircraft," by D. F. Folland, Sperry Gyroscope Company; October 4, 1949.

TOLEDO

Film: General Science, Electrical Radio; October 3, 1949.

WASHINGTON

"Application of Electronic Techniques in Medical Research," by S. A. Talbot, Johns Hopkins Hospital; October 10, 1949.

*SUBSECTION MEETINGS*

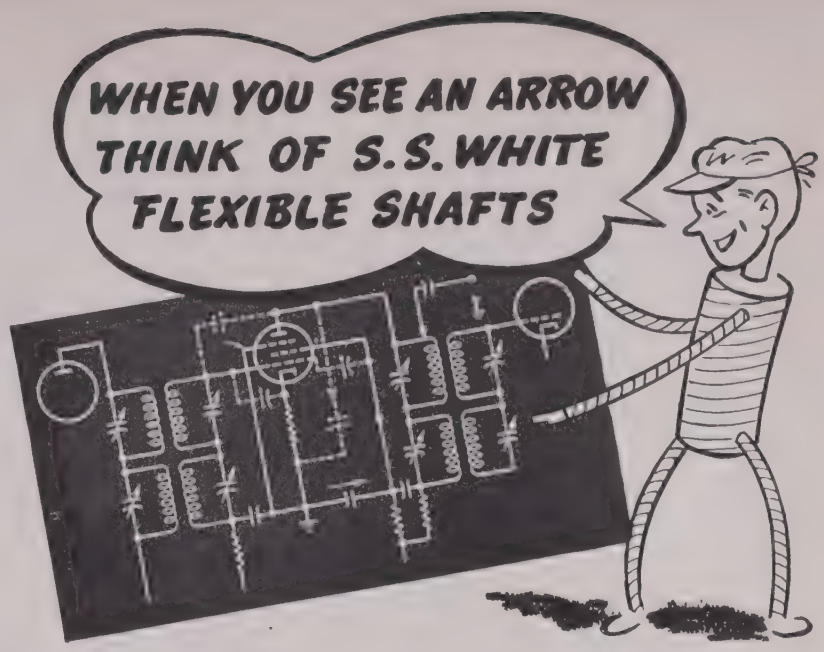
AMARILLO-LUBBOCK

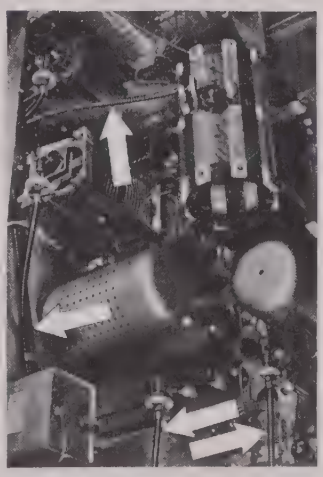
"FCC Rules and Regulations," by J. H. Homsy, FCC District 10; September 23, 1949.

LANCASTER

"RCA (Ground Control Approach) Past, Present and Future," by C. W. Hicks, Bendix Radio Division; October 12, 1949.

*(Continued on page 40A)*

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"As you know, an arrow through a symbol means a variable element. In a circuit diagram variable elements are no problem. You just draw them where you want them. But it's quite different when you come to design the actual equipment. Then, you have to consider electrical efficiency, operating convenience, ease of wiring, space economy, appearance and servicing.

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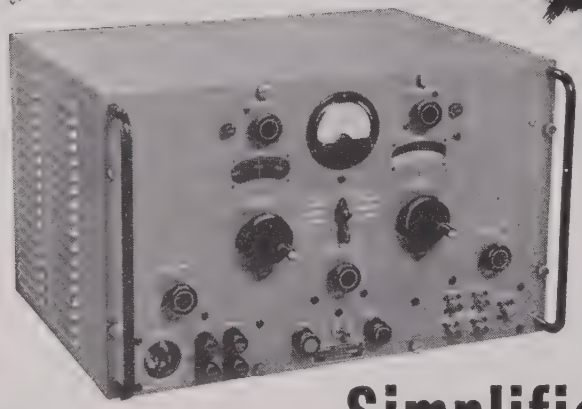

–Simplified
–Compact
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- Directly calibrated, single dial frequency control
- Directly calibrated attenuator, 0 to –120 dbm
- CW or AM pulse modulation
- Internal pulse generator with controls for width, delay, and rate. Provision for external pulsing
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*Built to Navy Specifications for research and production testing*

*Write for specifications — investigate the advantages of this outstanding new instrument.*

DEPENDABLE ELECTRONIC EQUIPMENT SINCE 1928

Aircraft Radio Corporation
BOONTON, New Jersey

## SECTION MEETINGS

*(Continued from page 39A)*

LONG ISLAND

"The Mine Detector of World War II," by L. F. Curtis, Hazeltine Electronics Corporation, and H. A. Wheeler, Wheeler Laboratories; October 11, 1949.

MONMOUTH

"Programming for a Large-Scale Digital Computer," by Joseph Weinstein, Signal Corps Engineering Laboratories; September 21, 1949.

NORTHERN NEW JERSEY

"A Report on the Scheduled FCC Hearing to Consider Proposals for a Change in TV Transmission Standards," by T. T. Goldsmith, Allen B. DuMont Laboratories; September 21, 1949.

## STUDENT BRANCH MEETINGS

CASE INSTITUTE OF TECHNOLOGY—IRE BRANCH

"Problems and Prospects of Television," by Russell Olsen, Chief Engineer, Radio Station WEWS-TV; October 4, 1949.

COLLEGE OF THE CITY OF NEW YORK—IRE BRANCH

"The Engineer's Job and the Engineering Society," by E. K. Gannett, Technical Editor, The Institute of Radio Engineers; October 4, 1949.

CLARKSON COLLEGE OF TECHNOLOGY—IRE BRANCH

Election of Officers; October 6, 1949.

UNIVERSITY OF COLORADO—IRE BRANCH

"A New Long-Range Navigational Aid; Console," by G. E. Glass, Faculty of University of Colorado; October 6, 1949.

CORNELL UNIVERSITY—IRE-AIEE BRANCH

"Solar Radiation and its Effect on Long-Distance Power Lines," by J. T. Wilson, Chief Physicist, Allis Chalmers Corporation; October 7, 1949.

"A Welcome to Freshmen," by H. B. Hansteen, Faculty of Cornell University; September 30, 1949.

UNIVERSITY OF FLORIDA—IRE-AIEE BRANCH

"Public Opinion the Ultimate Source of Power," by Seldon Waldo; September 29, 1949.

GEORGIA SCHOOL OF TECHNOLOGY—IRE BRANCH

"Wartime Radar," by M. A. Honnell, Faculty of Georgia School of Technology; October 13, 1949.

UNIVERSITY OF ILLINOIS—IRE-AIEE BRANCH

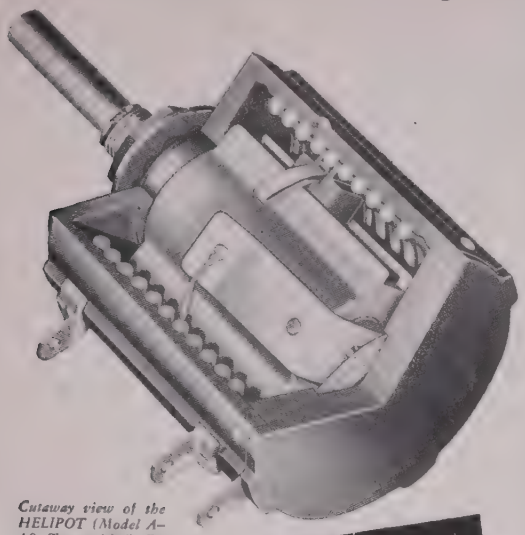
Speakers; Dr. Ryder, Head of Electrical Engineering Department, University of Illinois, and W. L. Everitt, Head of College of Engineering, University of Illinois; October 4, 1949.

IOWA STATE COLLEGE—IRE-AIEE BRANCH

"Industry and Your AIEE and IRE," by G. R. Town, Head of Experiment Station, Iowa State College; October 5, 1949.

*(Continued on page 42A)*

*For new simplicity, wide range, and high accuracy in the control of modern electronic circuits...*



*Cutaway view of the HELIPOT (Model A–10 Turn–1¾" Diameter)*

# THE BECKMAN Helipot

(Trademark of the HELical POTentiometer)

**Provides *many times* greater resistance control in *same* panel space as conventional potentiometers!**

IF YOU are designing or manufacturing *any type* of precision electronic equipment be sure to investigate the greater convenience, utility, range and compactness that can be incorporated into your equipment by using the revolutionary HELIPOT for rheostat-potentiometer control applications...and by using the new DUODIAL turns-indicating knob described at right.

*Briefly, here is the HELIPOT principle*...whereas a conventional potentiometer consists of a *single* coil of resistance winding, the HELIPOT has a resistance element *many times* longer coiled *helically* into a case which requires no more panel space than the conventional unit. A simple, foolproof guide controls the slider contact so that it follows the helical path of the resistance winding from end to end as a single knob is rotated. Result...*with no increase in panel space requirements*, the HELIPOT gives you as much as 12 times* the control surface. You get far greater accuracy, finer settings, increased range—with maximum compactness and operating simplicity!

### COMPLETE RANGE OF TYPES AND SIZES

The HELIPOT is available in a complete range of types and sizes to meet a wide variety of control applications..

**MODEL A:** *5 watts, 10 turns, 46" slide wire length, 1¾" case dia., resistances 10 to 50,000 ohms, 3600° rotation.*

**MODEL B:** *10 watts, 15 turns, 140" slide wire length, 3¼" case dia., resistances 50 to 200,000 ohms, 5400° rotation.*

**MODEL C:** *3 watts, 3 turns, 13⅓" slide wire length, 1¾" case dia., resistances 5 to 15,000 ohms, 1080° rotation.*

**MODEL D:** *15 watts, 25 turns, 234" slide wire length, 3¼ case dia., resistances 100 to 300,000 ohms, 9000° rotation.*

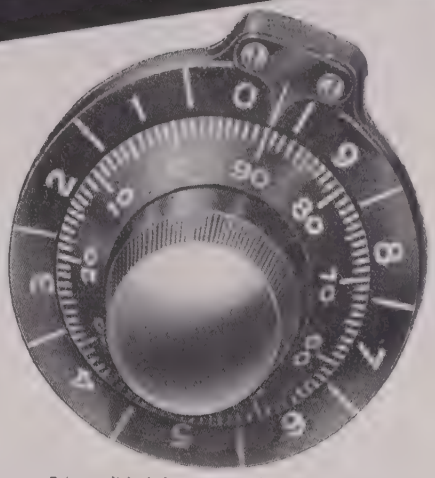
**MODEL E:** *20 watts, 40 turns, 373" slide wire length, 3¼" case dia., resistances 150 to 500,000 ohms, 14,400° rotation.*

Also, the HELIPOT is available in various special designs...with double shaft extensions, in multiple assemblies, integral dual units, etc.

Let us study *your* potentiometer problems and suggest how the HELIPOT can be used—possibly is already being used by others in your industry—to increase the accuracy, convenience and simplicity of modern electronic equipment. No obligation, of course. Write today outlining your problem.

**Data for Model A, 1¾" dia. Helipot. Other models give even greater control range in 3" case diameters.*

# THE BECKMAN Duodial



*The inner, or Primary dial of the* DUODIAL *shows exact angular position of shaft during each revolution. The outer, or Secondary dial shows number of complete revolutions made by the Primary dial.*

**A multi-turn rotational-indicating knob dial for use with the HELIPOT and other multiple turn devices.**

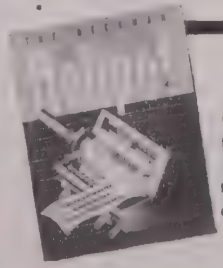
THE DUODIAL is a unique advancement in knob dial design. It consists essentially of a primary knob dial geared to a concentric turns-indicating secondary dial—and the entire unit is so compact it requires only a 2" diameter panel space!

The DUODIAL is so designed that—as the primary dial rotates through each complete revolution—the secondary dial moves one division on its scale. Thus, the secondary dial counts the number of complete revolutions made by the primary dial. When used with the HELIPOT, the DUODIAL registers *both* the angular position of the slider contact on any given helix as well as the particular helix on which the slider is positioned.

Besides its use on the HELIPOT, the DUODIAL is readily adaptable to other helically wound devices as well as to many conventional gear-driven controls where extra dial length is desired without wasting panel space. It is compact, simple and rugged. It contains only two moving parts, both made entirely of metal. It cannot be damaged through jamming of the driven unit, or by forcing beyond any mechanical stop. It is not subject to error from backlash of internal gears.

### TWO SIZES—MANY RATIOS

The DUODIAL is now available in two types—the Model "R" (illustrated above) which is 2" in diameter, and the new Model "W" which is 4¾" in diameter and is ideal for main control applications. Standard turns-ratios include 10:1, 15:1, 25:1 and 40:1 (ratio between primary and secondary dials). Other ratios can be provided on special order. The 10:1 ratio DUODIAL can be readily employed with devices operating *fewer* than 10 revolutions and is recommended for the 3-turn HELIPOT. In all types, the primary dial and shaft operate with a 1:1 ratio, and all types mount directly on a ¼" round shaft.



**Send for this HELIPOT AND DUODIAL CATALOG!**

Contains complete data, construction details, etc., on the many sizes and types of HELIPOTS...and on the many unique features of the DUODIAL. Send for your free copy today!

**THE Helipot CORPORATION, SOUTH PASADENA 6, CALIFORNIA**

a COMPLETE LINE of CAA APPROVED* TOWER LIGHTING EQUIPMENT BY Andrew

Designed for Dependability . . .
Immediate Delivery . . .

**300 MM CODE BEACON, Type 660.** Sturdily constructed, completely dependable. To provide steady, uninterrupted service for many years of exposure to rigorous weather conditions, metal parts are made of cast aluminum with hardware of corrosion resistant bronze. Insects are kept out by screens placed in ventilating openings.

**ISOFORMERS, Types 2015 and 2030.** Interlocking ring, air-insulated lighting transformers; particularly adapted for use with towers that develop a high voltage across the base insulator.

**REPLACEMENT LAMPS,** for code beacons and obstruction lights. Carried in stock in variety of filament voltages.

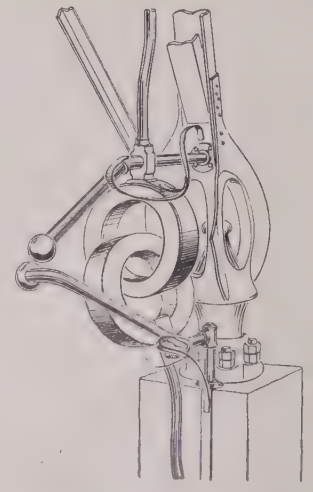
**LIGHTING FILTERS,** for use with insulated towers developing moderate voltages above 1 MC. Models available unhoused or in weatherproof steel housing.

**BURNOUT INDICATORS,** to show lamp failure.

**PHOTOELECTRIC CONTROL SWITCHES,** to turn tower lights ON and OFF.

**FLASHERS,** for code beacons.

**COMPLETE TOWER LIGHTING KITS,** including conduit, wire, and all fittings for towers of any height.



**SINGLE (Type 661A) and DOUBLE (Type 662A) OBSTRUCTION LIGHTS.** Easy to service, rugged, reliable. To replace burned out lamps, just loosen one thumb screw and open the two piece cast aluminum housing.

*Write for descriptive bulletins or further information—today.*

**CAA approvals cover only lighting fixtures themselves. Associated equipment is not subject to CAA regulations but more than meets all local regulations.*

Andrew CORPORATION
363 EAST 75th STREET CHICAGO 19

TRANSMISSION LINES FOR AM-FM-TV • ANTENNAS • DIRECTIONAL ANTENNA EQUIPMENT
ANTENNA TUNING UNITS • TOWER LIGHTING EQUIPMENT • CONSULTING ENGINEERING SERVICES
WORLD'S LARGEST ANTENNA EQUIPMENT SPECIALISTS

## STUDENT BRANCH MEETINGS

*(Continued from page 40A)*

STATE UNIVERSITY OF IOWA—IRE BRANCH

"Introduction to the Student Branch of the IRE," by L. A. Ware, Faculty of State University of Iowa; September 28, 1949

Films: Power and Light, and Curves of Color; October 5, 1949.

Field Trip; October 12, 1949.

Business Meeting; October 19, 1949

KANSAS STATE COLLEGE—IRE BRANCH

"Precipitation Static in Aircraft," by R. C Ayres, Chief Testing Engineer, Bendix Aviation Corporation; October 6, 1949

UNIVERSITY OF KENTUCKY—IRE BRANCH

Film: Unfinished Rainbows; October 11, 1949

LAFAYETTE COLLEGE—IRE-AIEE BRANCH

"The AIEE," by William Rohland, and "The IRE," by Robert Kudlich, Student Branch Officers; September 27 1949

MANHATTAN COLLEGE—IRE BRANCH

Business Meeting; October 12, 1949

UNIVERSITY OF MICHIGAN—IRE-AIEE BRANCH

"Preparing for Interviews," by W. C. Bergman, Michigan Bell Telephone Company; October 5, 1949

UNIVERSITY OF MISSOURI—IRE-AIEE

"How Co'Op Electricity Works," by R. J. Martin, Manager, Boone County R.E.A.; October 13 1949.

MISSOURI SCHOOL OF MINES AND METALLURGY —IRE-AIEE BRANCH

"Midgets of Telephone Science," by Mr. Mattick, Bell Telephone Company; and Election of Officers; October 6, 1949

NEWARK COLLEGE OF ENGINEERING— IRE BRANCH

Nomination of Officers; October 4, 1949.
Election of Officers; October 11, 1949.

UNIVERSITY OF NEW MEXICO—IRE BRANCH

Business Meeting; September 30, 1949.

NEW YORK UNIVERSITY—IRE BRANCH

Film: Adventures in Research; October 6, 1949.

UNIVERSITY OF NOTRE DAME— IRE-AIEE BRANCH

"The National Electronic Code," by John Brehmer, Electrical Contractor; September 28, 1949

OHIO STATE UNIVERSITY—IRE-AIEE BRANCH

"Recent Developments in Electron Tube Research," by E. M. Boone, Faculty of Ohio State University; "Magnatrons," by John Moll; "Klystron Oscillators," by James Ebers; and "Traveling Wave Tube," by George Muller; October 6 1949

OREGON STATE COLLEGE—IRE BRANCH

"The AIEE and IRE and Student Engineers," by F. O. McMillan, Head of School of Engineering Oregon State College; September 28, 1949.

"A New Personnel Program in the Pacific Telephone and Telegraph Company," by Bruce Pickett, Pacific Telephone and Telegraph Company; October 13, 1949

UNIVERSITY OF PENNSYLVANIA— IRE-AIEE BRANCH

Business Meeting; October 17, 1949.

*(Continued on page 44A)*

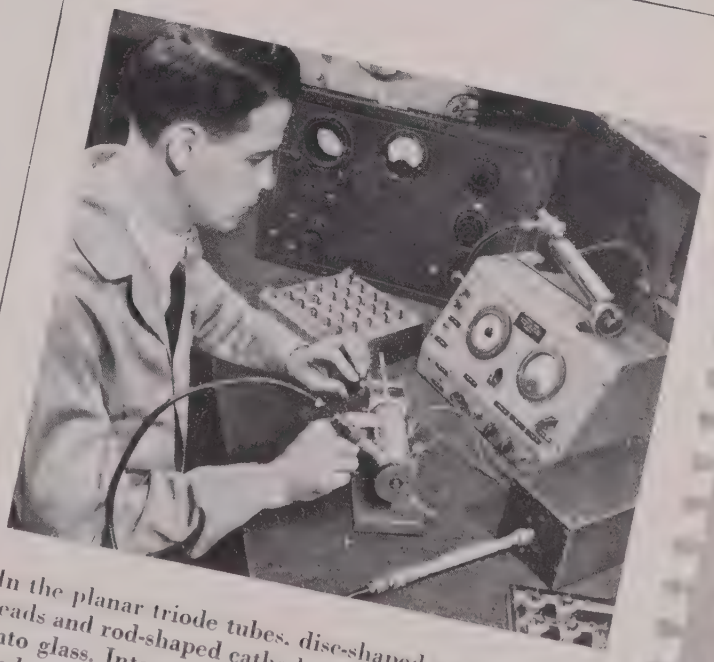
*A page from the note-book of Sylvania Research*

# Sylvania advances development and production of Planar Triode Tubes

The production of planar triodes in the Advanced Development Laboratories of Sylvania Electric at Kew Gardens, N. Y. bears small resemblance to standard receiving tube manufacture. The unusual design of the tubes eliminates conventional stem and mounting techniques. Instead individual tube elements, including plate, grid, and cathode are sealed directly into the glass envelope!

Sylvania is now producing several types of tubes in the planar triode family for direct application to microwave systems where frequencies range between 300 and 3000 mc. Used as pulse generators, some of these types will develop peak power outputs up to 200 watts.

Such results are typical of Sylvania's continuing research and determination to create new and better products.



*In the planar triode tubes, disc-shaped grid and plate leads and rod-shaped cathode leads are sealed directly into glass. Internal grids consist of fine parallel wires under tension to assure dimensional stability. Individual metal parts must be fabricated to precise dimension and contour for the requirements of microwave applications. Throughout manufacture, the greatest of care in handling, storage and application is required and maintained.*

# SYLVANIA ELECTRIC

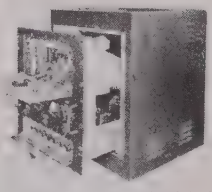
ELECTRONIC DEVICES: RADIO TUBES; CATHODE RAY TUBES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES, SIGN TUBING; LIGHT BULBS; PHOTOLAMPS

If the Problem is ELECTRONIC

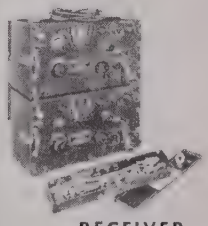
...look to B&W for the answer

2 KW AMPLIFIER

CONTROL UNIT



DUAL DIVERSITY CONVERTER



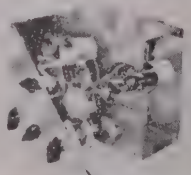
RECEIVER ASSEMBLY

From amplifiers to electronic repeaters . . . from diversity converters to complete receiver assemblies, test instruments and frequency multiplier units, B & W equipment is backed by men who have spent a lifetime in the electronic field . . . men who know the problems of radio and electronics and how to solve them.

Modern, up-to-date facilities are ready to convert the designs of these engineers into components or complete assemblies, designed and fabricated to withstand the toughest assignments and carrying the B & W trade-mark, recognized the world over for excellence.

B&W DISTORTION METER

B&W ALL BAND FREQUENCY MULTIPLIER



*Write for the latest B & W Catalog to: Dept. PR-129*

BARKER & WILLIAMSON, INC.

237 Fairfield Avenue Upper Darby, Pa.

*(Continued from page 42A)*

PRATT INSTITUTE—IRE BRANCH

Business Meeting; September 18, 1949.

"The Consulting Engineer," by T. C. Gams Industrial Electronics School; October 18, 1949.

RHODE ISLAND STATE COLLEGE—IRE-AIEE BRANCH

Business Meeting; September 27, 1949.

RUTGERS UNIVERSITY—IRE-AIEE BRANCH

"Function of Personnel Placement Division," by William Hobbie; October 11, 1949.

SYRACUSE UNIVERSITY—IRE-AIEE BRANCH

"Engineers in Russia," by Igor Plusc, Faculty of Syracuse University; Nomination of Officers; September 28, 1949.

"Working in a Power Plant," by D. Y. Brouse, Student; October 12, 1949.

SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY—IRE BRANCH

Business Meeting; September 28, 1949.

TEXAS AGRICULTURAL AND MECHANICAL COLLEGE—IRE-AIEE BRANCH

Business Meeting; Election of Officers; October 11, 1949

UNIVERSITY OF UTAH—IRE-AIEE BRANCH

"Orientation to Activities of AIEE-IRE," by O. C. Haycock, Faculty of University of Utah; October 4, 1949.

VIRGINIA POLYTECHNIC INSTITUTE—IRE BRANCH

Business Meeting; September 27, 1949.

"Graduate Work in Electrical Engineering," by F. C. Vilbrandt, Head of Chemical Engineering Department, Virginia Polytechnic Institute; October 4, 1949.

Films: Coaxial Cable, Antennas and Microwaves, and Station Installer; October 18, 1949.

"Analaogy Between Fluid Flow and Electric Current," by V. G. Szebehely, Faculty of Virginia Polytechnic Institute; October 11, 1949

WAYNE UNIVERSITY—IRE-AIEE BRANCH

Business Meeting; September 27, 1949.

**The following transfers and admissions were approved and will be effective as of December 1, 1949:**

**Transfer to Senior Member**

Black, R. R., 2203 U Pl., S. E., Washington 20 D. C.

Fisher, W. C., RCA Victor Company, Ltd., 168 Market Ave., E., Winnipeg, Man., Canada

Gregory, L. W., 108 Oaklee Village, Baltimore 29, Md.

Hedeman, W. R., Jr., 908 Greenleigh Rd., Baltimore 12, Md.

Hughes, W. R., 11600 Sherman Way, N Hollywood, Calif.

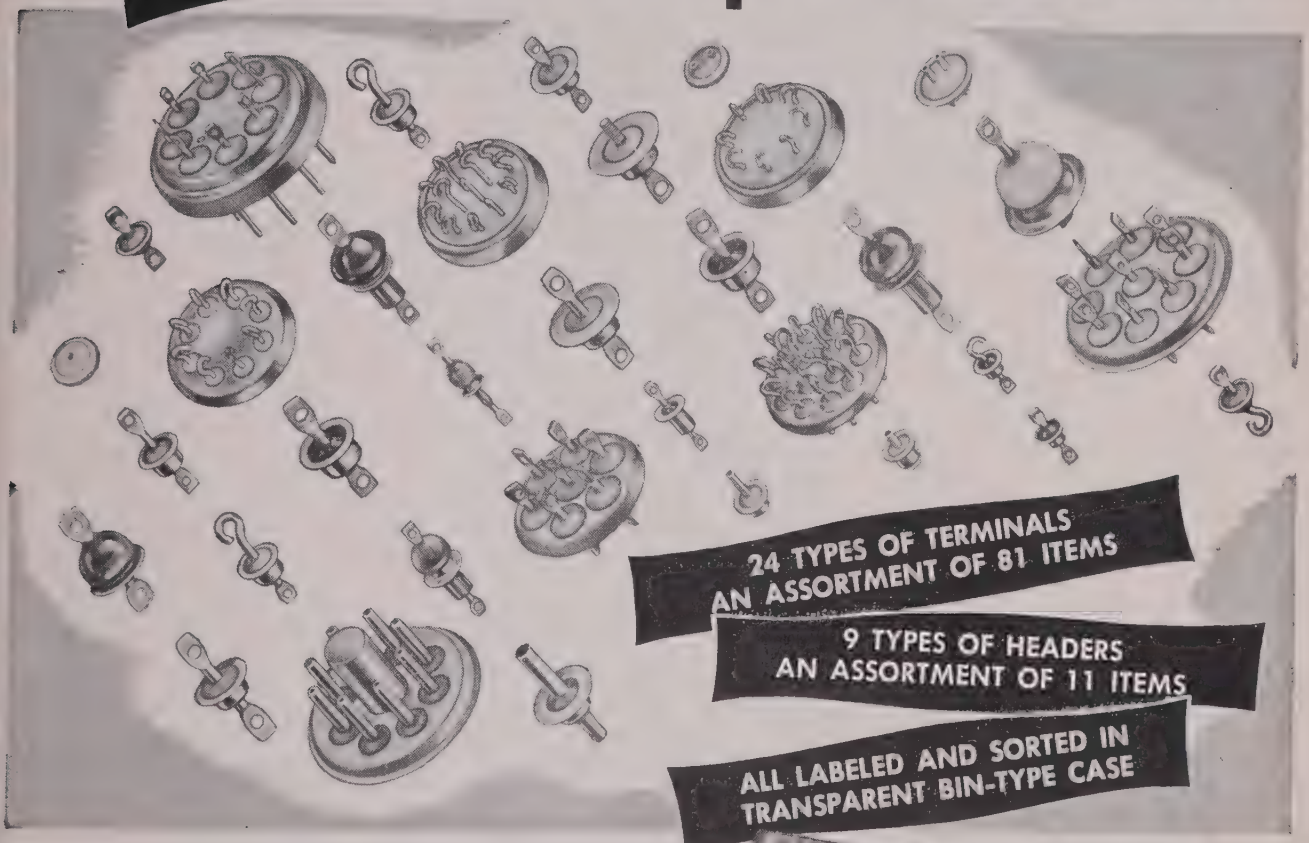
Kramer, A. S., 377 S. Second St., Lindenhurst, L. I. N. Y.

*(Continued on page 46A)*

Solve your SEALED LEAD problems in SECONDS—

— WITH THE NEW ENGINEER-DESIGNER

# E-I sealed lead and multiple header kit!



24 TYPES OF TERMINALS
AN ASSORTMENT OF 81 ITEMS

9 TYPES OF HEADERS
AN ASSORTMENT OF 11 ITEMS

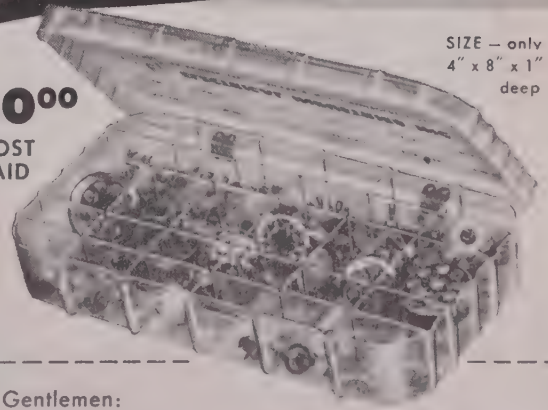
ALL LABELED AND SORTED IN TRANSPARENT BIN-TYPE CASE

## E-I DESIGN SAMPLES

***SAVE YOU TIME AND MONEY!***

Kit contains 81 standard terminals and 11 different header types. E-I standard leads and headers can solve practically all problems on hermetic seals at prices that benefit from standardized mass production. For unusual requirements E-I custom manufacture can meet your needs—economically. Use an E-I Sample Kit to find the right type for your production—you'll find it practical, fast and above all, economical!

***JUST FILL OUT COUPON AND MAIL WITH CHECK OR MONEY ORDER!***



SIZE — only 4" x 8" x 1" deep

**$10.00** POST PAID

Gentlemen:

Enclosed is $10.00 for my E-I Sample Kit. Please send it at once.

NAME.....

COMPANY.....

STREET.....

CITY.....STATE.....

(Please print clearly)

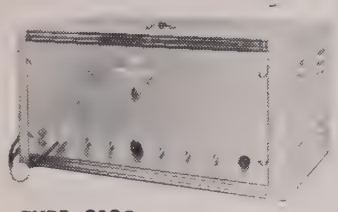
E-I INC

**ELECTRICAL INDUSTRIES · INC**

**44 SUMMER AVENUE, NEWARK 4, NEW JERSEY**

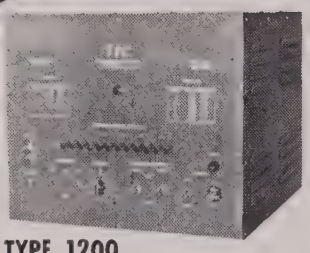
# A Complete Line of PRODUCTION TEST EQUIPMENT for TV Manufacturers

**Tel-Instrument has designed and provided the production test equipment for many of the major TV manufacturers. A complete line of instruments designed to be unusually critical in the testing of TV receivers is available. They are the result of the wide practical experience of Tel-Instrument engineers plus a complete understanding of the production problems of TV manufacturing.**



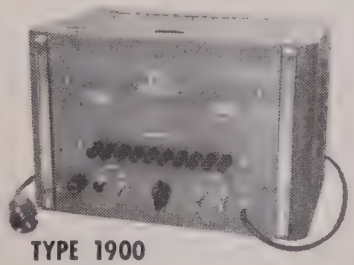
**TYPE 2120**
**R.F. PICTURE SIGNAL GENERATOR**

Provides picture and sound carrier. Modulated by standard R.M.A. composite picture signal. Sound carrier stability suitable for testing Inter Carrier type receivers. Internal 400 cycle FM and External audio with 75 microsecond pre-emphasis. Output max. 0.1v p-p across 75 ohm line. Available channels 2-13.



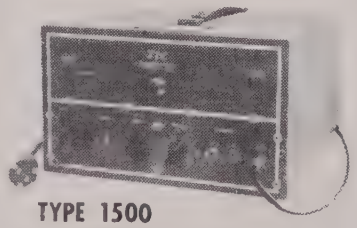
**TYPE 1200**
**12 CHANNEL**
**R.F. SWEEP GENERATOR**

Intended for precise adjustment of R.F. head oscillator coils and R.F. band pass circuits. Pulse type markers at picture and sound carrier frequencies extend to zero signal reference base line. Accuracy of markers 0.02% of carrier frequency. 12 to 15 MC. sweep on all channels. Max. 1.V peak output across a 75 ohm line. Provisions for balanced input receivers. Instant selection by push button.



**TYPE 1900**
CRYSTAL CONTROLLED
**MULTI-FREQUENCY GENERATOR**

A 10 frequency, 400 cps. modulated crystal controlled oscillator, ideal for production line adjustment of stagger tuned I.F. amplifiers. Available with crystals ranging from 4.5 to 40 M.C. Output frequency accurate to 0.02%. Immediate push button selection of frequency. Output attenuator range .5V to 500 microvolts. Self contained regulated power supply.



**TYPE 1500**
**I.F. WOBBULATOR**

A two band sweeping generator covering the range of 4.5 to 50 M.C. Capable of a band width of approximately ±25% on either band. Five pulse type crystal generated markers to specified frequencies available for each band. Accuracy of markers .05%. Zero signal reference base line, with markers extending to base line. 1.V output max. into 75 ohms. A saw sweep available for "X" axis of scope.

*Write for Detailed Engineering Data Sheets.*

**Tel-Instrument Co. Inc.**
**54 PATERSON AVENUE • EAST RUTHERFORD, N. J.**


## MEMBERSHIP

*(Continued from page 44A)*

Lear, W. E., 418 N. Yulee St., Gainesville, Fla
Mayo-Wells, W. J., 5938 13 Pl. N.W., Washington 11, D. C.
Millman, J., 144-54-69 Ave., Flushing, L. I., N. Y.
Schwetman, H. D., Physics Department, Baylor University, Waco, Tex.
Soria, R. M., 1830 S. 54 Ave., Chicago 50, Ill
Straiton, A. W., Department of Electrical Engineering, University of Texas, Austin, Tex
Thorson, H. L., 1517 Wyoming Ave., Schenectady N. Y. (effective November 1)
Vogt, E. J., 2200 N. Tejon St., Colorado Springs, Colo.
Webber, S. E., Research Laboratory, General Electric Company, Schenectady, N. Y.
Welge, V., 432 LaCrescentia Dr., San Diego, Calif
Wolf, H., 114-01—86 Ave., Richmond Hill, L. I., N. Y.

### Admission to Senior Member

Beck, V. R., 254 Grantley, Elmhurst, Ill.
Pack, L., 128 Russell Lane, London N. 20, England
Watson, S. H., Chews Landing Rd. cor. Hutchinson Ave., Haddonfield, N. J.
Willoughby, J. A., Federal Communications Commission, Washington 25. D. C

### Transfer to Member

Brewer, G. R., 1359 Erving Ct., Willow Run Village, Mich.
Cholmondeley-Smith, D. R., Transmitting Station New Zealand Broadcasting Service, Opapa Hawke's Bay, New Zealand
Douglass, C. F., 19 W. Fifth St., Emporium, Pa
Fulmer, N. C., 16 Forest St., Montclair, N. J.
Gerlough, D. L., Department of Engineering, University of California, Los Angeles, Calif.
Hanft, H., 711 New Jersey Ave., Brooklyn 7, N.Y.
Hyland, F. G., 1394 N. Fifth St., Columbus, Ohio
Johnson, L. E., The Pines, R. R. 3, Wayzata, Minn.
Kong, Y., 26-3 W. Wai Oy Rd., Canton, China
Martin, R. A., 210 North Ave., N.W., Atlanta 3 Ga.
McCall, E. A., 3504 E. 26 St., Kansas City, Mo
Nord, R. H., Box 6, Bayside, L. I., N. Y
Occhiogrosso, T., 84 Barker Ave., Eatontown, N. J.
Roney, E. L., 479 Pacific St., San Luis Obispo Calif.
Stultz, L. R., 46 Westcliff Rd., Colonia, N. J.
Waxler, B., 1956 Bathgate Ave., New York 57, N. Y

### Admission to Member

Brenneman, D. E., Bell Telephone Laboratories, 463 West St., New York 14, N. Y.
Cameron, D. B., National Carbon Company, Inc. Box 6087, Cleveland, Ohio
Fox, W. C. O., Thornycroft Apartments, Garth Rd., Scarsdale, N Y
Hewitt, F. J., 4 Orange St., Sandringham, Johannesburg, South Africa
Hults, E. H., 18 Milburn Ct., Baldwin, N. Y.
James, W. S., Jr., 200 Highland Blvd., Brooklyn 7, N. Y.
Khouri, J. O., Direction Telephonique, Beyrouth, Lebanon
LaVielle, W. R. R., 495 Lightfoot Rd., Louisville, Ky.
Loreto, D. R., 62 Sicard St., New Brunswick, N. J.
Mayerson, M. I., 41 Barker Ave., Eatontown, N. J.
Mleczko, E. L., 7619 Hinds Ave., N. Hollywood, Calif.
Perry, R. L., 259 Saratoga Ave., Los Gatos, Calif
Pratt, C. B., 11 Halsey Dr., Dayton 3, Ohio
Robinson, W. H., 29 Bartlett Ave., Arlington 74 Mass.
Ruark, A. E., 1315 St. Paul St., Baltimore 2, Md.
Shaw, A. B., 316 W. 44 St., New York 18, N. Y.
Sirota, N., 10 E. 57 St., Brooklyn, N. Y.
Thomas, L. R., 830 Park Ave., Wilmette, Ill.

*(Continued on page 47A)*

## MEMBERSHIP

*(Continued from page 46A)*

**The following elections to the Associate grade have been approved and will be effective as of November 1, 1949:**

Abert, E. P., 108 Forest Dr., North Syracuse, N. Y.
Accardo, N. A., 267 Montclair Ave., Vaux Hall, N. J.
Amaitis, E. J., 310 S. Third St., Brooklyn 11, N. Y
Baker, W. L., Box 881, State College, Pa.
Benson, E. D., 70 Forsyth St., Boston, Mass
Bettis, W. E., 3328 T. S., Box 220, Scott Air Force Base, Ill
Binkholder, C. E., c/o American Television Institute, 5050 Broadway, Chicago, Ill.
Brandt, R. W., 4545 W Augusta Blvd., Chicago 51, Ill.
Bross, C. F., 5 E. P. Bross, R.R. 3, Palmyra, Mo
Buersmeyer, C. R., Box 371, Washington, Mo.
Burgar, D. G., 2178 Ave. H, Redondo Beach, Calif
Burgard, G. J., Maple Ave., Evans City, Pa.
Clark, D., Jr., 40270 Abourne Rd., Los Angeles, Calif.
Cloutier, D. A., 4545 W. Augusta Blvd., Chicago 51, Ill.
Coffey, J. L., 32 Oak Island Rd., Revere 51, Mass
Cooper, W. C., 3960 Ogden, Beaumont, Tex.
Cotellessa, R. F., Box 162, 472 Van Emburgh Ave., Ridgewood, N. J.
Crupi, D. W., 5050 Broadway, Chicago, Ill.
Das, J., West Command Signal Regiment, New Delhi, India
Daykin, D. R., 1283 Clifton Prado, Lakewood Ohio
De Cubas, J. D., 20 Christopher St., New York 14, N. Y.
De Socio, G., 702 Evesham Ave., Baltimore 12, Md
Dilger, L. E., 3617 N. 79 St., Milwaukee 13, Wis.
Dobbins, W. E., 217—17 St., Manhattan Beach, Calif.
Dolence, J. J., 918 E. 14 Pl., Chicago 15, Ill.
Duschenchuk, L., 148 Newport Rd., E. Hempstead L. I., N. Y.
Dyett, E. G., Jr., 29 William St., Cambridge 39 Mass.
Elliott, J. W., 1157 W. 11 St., San Pedro, Calif.
Ellis, C. E., Jr., 204 Fostoria Ave., Springfield, Ohio
Farrell, P. T., 495 E. 188 St., New York 58, N. Y
Fegley, K. A., 200 S. 33 St., Philadelphia 4, Pa.
Fields, T., 6917 S. Crandon Ave., Chicago 49, Ill.
Fong, B. W., 1129 Stockton St., San Francisco, Calif.
Friedberg, I. S., 86 W. 183 St., New York 53, N. Y
Fuller, B. L., 4024 Hillcrest Dr., Los Angeles 43, Calif.
Gerold, L., 53 Prairie Lane, Levittown, Hicksville, L. I., N. Y.
Green, C. A., Sioux Ordnance Depot, Sidney, Nebr
Greer, L. H., 26 W. 47 St., New York 19, N. Y.
Hardy, W. G., 807 Columbus Ave., New York 25 N. Y.
Harvey, F. K., Bell Telephone Laboratories, Murray Hill, N. J.
Hausenbauer, C. R., College of Engineering, University of Arizona, Tucson, Ariz.
Heckert, R. E., 1203 S. Berendo St., Los Angeles 6, Calif.
Hedges, H. G., 519 Roy Ave., Dayton 9, Ohio
Holt, T., 2301 Gantz Rd., Grove City, Ohio
Honda, H., 36 N. 34 St., Philadelphia, Pa
Hopf, E. W., 324 William St., Boonton, N. J.
Houlroyd, G. F., Boonton Radio Corp., Intervale Rd., Boonton, N. J.
How, F., South African Broadcasting Corporation Commissioner St., Johannesburg, Transvaal, South Africa
Jones, S., 104-45—121 St., Richmond Hill, L. I. N. Y
Kantor, F. I., 3869 Sedgwick Ave., New York 63, N. Y.

*(Continued on page 48A)*

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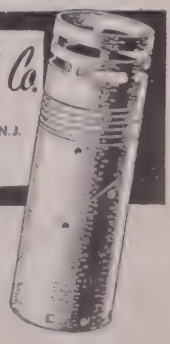

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Laboratory and Research Instruments
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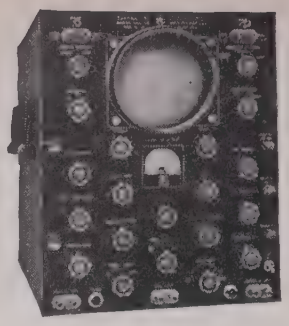
OSCILLOSYNCHROSCOPE
Model OL-15B



Designed for maximum usefulnes in laboratories doing a variety of research work, this instrument is suited to radar, television, communication, facsimile, and applications involving extremely short pulses or transients. It provides a variety of time bases, triggers, phasing and delay circuits, and extended-range amplifiers in combination with all standard oscilloscope functions.

*THESE FEATURES ARE IMPORTANT TO YOU*

- Extended range amplifiers: vertical, flat within 3 db 5 cycles to 6 megacycles, full tube deflection; horizontal, flat within 1 db 5 cycles to 1 megacycle.
- High sensitivity: vertical, 0.05 RMS volts per inch; horizontal 0.1 RMS volts per inch.
- Single-sweep triggered time base permits observation of transients or irregularly recurring phenomena.
- Variable delay circuit usable with external or internal trigger or separate from scope.
- Sawtooth sweep range covers 5 cycles to 500 Kilocycles per second.
- 4,000-volt acceleration gives superior intensity and definition.

For complete data, request Bulletin RO-912

SWEEP CALIBRATOR

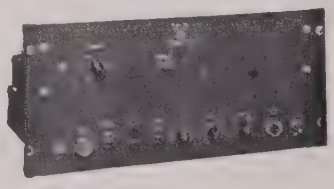
Model GL-22A

This versatile source of timing markers provides these requisites for accurate time and frequency measurements with an oscilloscope:

- Positive and negative markers at 0.1, 1.0, 10, and 100 micro-seconds.
- Marker amplitude variable to 50 volts.
- Gate having variable width and amplitude for blanking or timing.
- Trigger generator with positive and negative outputs.

Further details are given in Bulletin RC-912.

SQUARE-WAVE MODULATOR AND POWER SUPPLY



Model TVN-7

Here is the heart of a super high frequency signal generator with square-wave, FM, or pulse modulation. Provides for grid pulse modulation to 60 volts, reflector pulse modulation to 100 volts, square-wave modulation from 600 to 2,500 cycles. Voltage regulated power supply continuously variable 280-480 or 180-300 volts dc. For additional data and application notes, see Bulletin RM-912.

STANDING WAVE RATIO METER AND HIGH GAIN AUDIO AMPLIFIER

Model TAA-16

- Standing wave voltage ratios are read directly on the panel meter of this sensitive, accurate measuring instrument.
- Frequency range 500 to 5,000 cycles per second.
- Two input channels with separate gain control for each.
- "Wide-band" sensitivity 15 microvolts full scale.
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*(Continued from page 47A)*

Karns, K. B., Hayes Center, Nebr.
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Lock, R. W., 6228 N. Winthrop Ave., Chicago 40 Ill.
Marek, L. W., 215 W. 23 St., New York 11, N. Y.
Martin, P. W., 3019 Walnut St., Huntington Park, Calif.
Maass, C. F., 516 E. South St., Anaheim, Calif.
McKay, M. W., 2368 Victory Pkwy., Cincinnati 6, Ohio
Myers, E. G., 102½ S. Flenoaks Blvd., Burbank, Calif.
Neill, W. R., Box 131, Medway, Ohio
Newman, H. S., R. D. 1, Kent, Ohio
Nitsche, J. E., Corning Glass Works, Corning, N. Y.
Patrick, P. J., Box 2386, Anchorage, Alaska
Perkins, G. M., General Delivery, China Lake, Calif.
Pickens, G. O., Box 295, Point Loma, San Diego Calif.
Press, M., 46-40—189 St., Flushing, L. I., N. Y.
Quavraux, H. F., 1031 N. Bonnie Brae, Los Angeles Calif.
Rai, R. K., 5 Ridge, Nagpur, India
Rhode, F. S., Box 22, Valparaiso, Ind.
Rice, J. W., 272 Union St., Ashland, Mass
Roberts, L. L., Jr., 4353 S. Van Buren Pl., Los Angeles, Calif
Rooten, A., 702 Smith Ave., Xenia, Ohio
Sauer, R. D., 57 Anchor Lane, Levittown, L. I N. Y
Scott, D. E., 16508 Eastburn, Detroit, Mich
Sear, H., Gladstone Hotel, 11 and Pine St., Philadelphia, Pa.
Seybold, R. E., 2803 Summit, Toledo 11, Ohio
Shaw, B., 321 Ave. C, New York 9, N. Y.
Shuman, H., 39 Baird St., Dorchester 24, Mass.
Smith, J. G., 15026 Talman Ave., Harvey, Ill.
Soloway, M. D., 1929 Haight Ave., New York 61, N. Y.
Sparks, W. J., Jr., 134 W. 21 St., Indianapolis, Ind.
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Stanton, W. R., 225 Mt. Pleasant Ave., Stratford Conn.
Taischoff, J., 30 Rockefeller Plaza, New York 20, N. Y.
Thresh, J. L., 375 Carroll Park, E., Long Beach 14, Calif.
Tippott, D. W., 1405—36 St., Sacramento, Calif.
Venketakrishnan, R., 40 Edward Elliot Rd: Mylapore, Madras, India
Volpe, D. F., 316 E. 22 St., Paterson 4, N. J.
Walker, E. T., 1627 Russell Ave., Dayton, Ohio
Weber, G. J., 1525 Sampson St., Los Angeles 33, Calif.
Weber, S. E., 205 W. Second St., Arcanum, Ohio
Wightman, B. A., National Research Council Sussex St., Ottawa, Ont., Canada
Wilson, C. R., 91-21—195, Hollis, L. I., N. Y.
Wong, G. W., 66 University Rd., Brookline 46, Mass.
Wynn, J. D., Jr., Box 1186, Port Hueneme, Calif.
Yarbrough, K. A., 6038 Bryan Pkwy., Dallas 5, Tex.
Young, R. O., 620 W. 115 St., New York 25, N. Y.
Zegers, T. A., 2652 Hudson Blvd., Jersey City 6, N. J.

**The following transfers to the Associate grade were approved to be effective as of October 1, 1949:**

Aburano, F., 2007 Main St., Seattle 44, Wash.
Adams, M. M., 404 Choctaw, Bartlesville, Okla.
Adovnik, F. W., 1013 Lee St., Rock Springs, Wyo.
Alley, R. P., 173 Burbank, Pittsfield, Mass.
Brill, G. J., 836 Masonic Ave., San Francisco 17, Calif.
Buescher, W. E., 220 West Fourth St., Emporium, Pa.
Burgwald, G. M., 10628 Ave. F., Chicago 17, Ill.
Clemens, J. F., 612 College Highway, Evansville, Ind.

*(Continued on page 49A)*

## Membership

*(Continued from page 48A)*

Crill, P. D., 125-12 Street, Oakland, Calif
De Carlo, G. J., 1133 Waring Ave., New York 67, N. Y.
Dick, A. I., 283 E. 171 St., New York 57, N. Y.
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Findley, R., 515 Taylor Ave., Avalon, Pittsburgh 2, Pa.
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Hammond, W. H., 1 Collier Rd., N.W., Atlanta, Ga.
Hart, M. T., 437 S. Poplar, Centralia, Ill.
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Kugler F., 291 Rockaway Pkwy. Brooklyn 12, N. Y
Lamb, H. M., 58 Barnyard Lane, Levittown, Hicksville, L. I., N. Y.
Lang, H. J., 100 Franklin St., Bldg. 1, Apt. A3 Morristown, N. J.
Manry, L. V., Jr., 4324 Betty St., Bellaire, Tex.
Mew, H. Y., 1326 Alewa Dr., Honolulu 29, Hawaii
Meyer, D. R., 7260 Bellaire Ave., North Hollywood, Calif.
Miller, R. L., Box 95, Parkland, Pa.
Mueller, H. W., 2428 N. Holton St., Milwaukee 12 Wis.
Perkins, G. O., 314 W. Zeralda St., Philadelphia 44, Pa.
Peterson, C. D., 11117 Edbrooke Ave., Chicago 28 Ill.
Rau, F. J., 1015 Uvilla St., Pittsburgh 20, Pa
Reber, J. H., 120 W. Maple Ave., Osborn, Ohio
Robinson, W. C., c/o W. B. Manchester, R.F.D. 3, Ithaca, N. Y
Ryff, A. S., 22915 Pleasant, St. Clair Shores Mich.
Scher, G. P., 529 Allen St., South Bend 16, Ind
Schnebbe, A. D., Michael St., Menlo Park, N. J
Schreiner, R. J., 34 Pier St., Yonkers 5, N Y
Stroble, R. R., Box 104, La Porte, Tex
Strong, J. J., Jr., 28-19 Hobart St., Woodside, L. I., N. Y.
Thompson, C. E., Box 89, Canyon, Tex
Wells, W. S., Box 521, Rapid City, So. Dak.
White, J. F., Jr., 5459 Iowa St., Chicago 41, Ill
Winkelstein, R. A., 39 Vernon Ave., Mount Vernon, N. Y.
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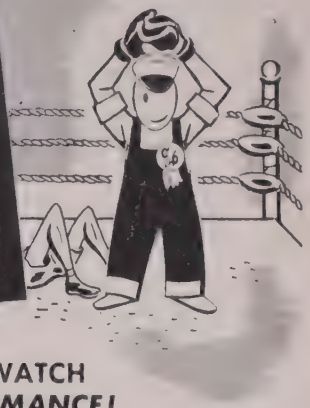
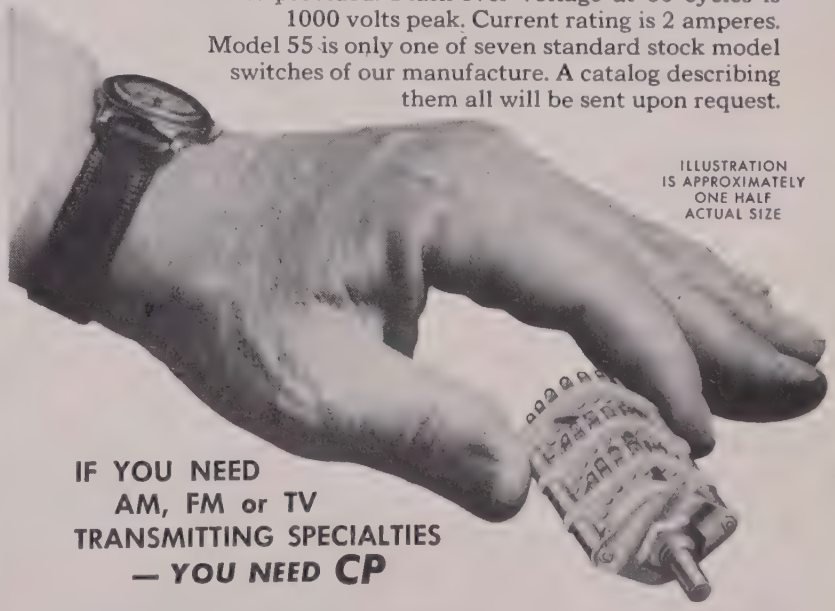
it's the new CP
MODEL 55 SWITCH
FOR RF AND
POWER SERVICE



NO BIGGER'N A WRISTWATCH
*BUT PACKED WITH PERFORMANCE!*

The new model 55 shorting type switch reflects, in miniature, many design features of large CP switches. With a maximum of 18 contact positions in the single pole style, it's also available in two or three pole styles. Of course several sections may be "ganged". Silver path from terminal to terminal is provided. Flash-over voltage at 60 cycles is 1000 volts peak. Current rating is 2 amperes. Model 55 is only one of seven standard stock model switches of our manufacture. A catalog describing them all will be sent upon request.



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## Highly Qualified Engineers and Physicists Needed

**Development of:**
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Microwave components
UHF and VHF antennas
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Problems are related to commercial and military aircraft and guided missiles. Employment is stable and offers ample opportunity for advancement to those able to assume responsibility. Present staff includes highly qualified physicists, engineers and mathematicians and ensures a stimulating professional environment. Liberal patent and publication policy. Several years experience plus advanced degree or equivalent required.

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*Physicist*—Dielectric theory and practice.

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These positions open with a long established, progressive midwest radio component manufacturer, having a reputation for the development of important new components in the Radio and Television field. Experience and a definite record of accomplishment in the above fields are prerequisites of employment

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## POSITIONS OPEN

The following positions of interest to I.R.E. members have been reported as open. Apply in writing, addressing reply to company mentioned or to Box No. ...

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Southern, G.I. approved, private vocational school desires capable man to take charge of teaching courses in radio and television. Salary $300 to $350 per month. Scholastic hours. Teaching experience preferred. Write Mr. J. D. Muse, P.O. Box 505, Atlanta, Georgia.

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Fully qualified. Accustomed to working with small electromechanical devices. Write Mr. D. A. Murray, Mount Dennis, Toronto 15, Canada.

### ELECTRONIC ENGINEER

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### DEVELOPMENT ENGINEERS

All grades with degrees and experience in design and development of high quality instruments for research in physics, chemistry, etc. Applicant will be required to design and develop electrical, electronic and mechanical instruments for the nuclear field. Salary commensurate with ability to produce a final working model from the idea state. Box 577.

### ELECTRONIC TECHNICIANS

For work in laboratory, assembling, wiring and testing of precision electronic design models. Applicants must have at least three years of similar experience and must be capable of producing the highest quality work. Box 577.

### ENGINEER

Wanted, new electronic ideas, company with capital and manufacturing facilities is seeking new electronic products, inventions, or ideas to expand commercial business. Liberal arrangements with inventors. Box 578.

### ENGINEERS

Electrical or electronic engineers with experience in magnetic recording techniques and/or systems, preferably in the computer field. Box 579.

### ENGINEER

A government-supported project with a college in NYC has an opening for an experienced vacuum tube development engineer. Duties are technical-administrative, with opportunity to initiate and conduct research part-time. State qualifications and salary requirements. Box 580.

### ELECTRICAL ENGINEERS

Highly interesting research and design positions are open at Army Security

*(Continued on page 51A)*


## PHYSICISTS AND ENGINEERS

This expanding scientist-operated organization offers excellent opportunities to alert physicists and engineers who are interested in exploring new fields. We desire applicants with experience in the design of electronic circuits (either pulse or c. w.), computers, gyros, antennas, or precision mechanical instruments. A few openings for Junior Engineers and Technicians also exist. This company specializes in research and development work. Laboratories are located in suburbs of Washington, D.C.

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# SWIFT, SURE FREQUENCY COMPARISON

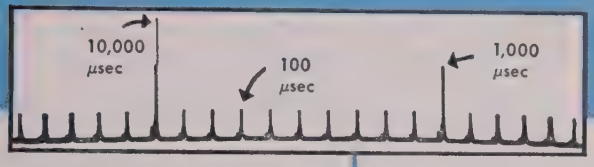


FIG. 1. Timing Comb, -hp- Model 100D

## NEW hp SECONDARY FREQUENCY STANDARDS

### MODELS 100C AND 100D

- Sine or rectangular waves
- 100 μsec time markers
- Built-in oscilloscope
- Stability 1/1,000,000
- Low output impedance
- New, improved circuits
- Audio, supersonic, rf measurements

## SPECIFICATIONS

**-hp- 100D Secondary Frequency Standard**

**Accuracy:**
About 2 parts per million per week, normal room temperature.

**Stability:**
About 1 part per million over short intervals.

**Output:**
Controlled frequencies: 100 kc, 10 kc, 1 kc, 100 cps, 10 cps. Sine or rectangular waves; marker pips. Internal impedance approx. 200 ohms.

**Wave Shape:**
Sine wave: less than 4% distortion into 5,000 ohms or higher load.

**Marker Pips:**
10,000, 1,000 and 100 μsec intervals.

**Oscilloscope:**
Integral with circuit. Establishes 10:1 Lisajous figures to show division ratio. May be used independently of standard.

**-hp- 100C Secondary Frequency Standard**

**Accuracy:**
Within ± .001% normal room temperature.

**Output:**
Controlled frequencies of 100 kc, 10 kc, 1 kc, and 100 cps. Internal impedance approx. 200 ohms.

**Wave Shape:**
Sinusoidal only. 4% distortion into 5,000 ohm load.

**Power Supply:**
(100C and 100D) 115 v, 50/60 cps, regulated to minimize line voltage fluctuations. Power drawn approx. 150 watts.

**Mounting:**
(100C and 100D) Cabinet or relay rack. Panel 19" x 10½". 12" deep.

*Data Subject to Change Without Notice*

The new *-hp-* 100C and 100D Secondary Frequency Standards incorporate all the features of the time-tested *-hp-* models 100A and 100B, plus important new advantages including rectangular wave output, timing pips, and an internal oscilloscope for convenient frequency comparison. The *-hp-* 100D may be conveniently standardized against station WWV with a minimum of external equipment, and thus provide most of the advantages of an expensive primary standard.

### Crystal Controlled Frequencies

The new *-hp-* Models 100D and 100C employ a crystal-controlled oscillator and divider circuits offering a new high in stability and simplicity of operation. Standard frequencies are available through a panel selector switch, and may be employed simultaneously. Internal impedance is low (about 200 ohms), so that standard frequencies can be delivered at some distance from the instrument.

The *-hp-* 100D Secondary Frequency Standard offers sine waves at 5 frequencies and rectangular waves at 4 frequencies, plus a built-in oscilloscope. The instrument also provides a timing comb with markers 100, 1,000 and 10,000 microsecond intervals. Rectangular wave output has a rise time of approximately 5 microseconds. Accuracy is 2 parts per million.

### 5 v. at all Frequencies

The more moderately priced *-hp-* 100C Standard offers sinusoidal frequencies at 4 crystal-controlled frequencies and, like the *-hp-* 100D, provides 5 volts of output at all frequencies. Accuracy .001%,

Both models operate from a 115 v. ac power supply, and power is regulated to minimize power line voltage fluctuations.

*Get full details . . . see your -hp- representative or write direct . . . today!*

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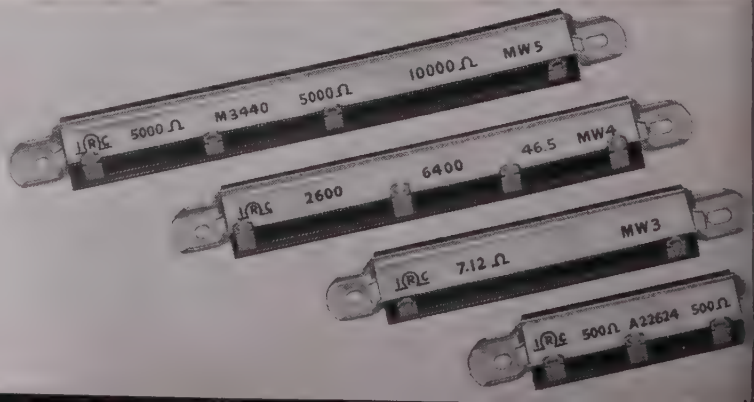
# Power problems can

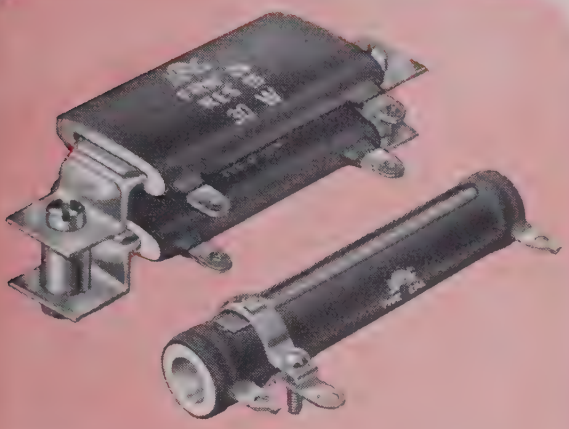
*for resistors too!*

. . . But the most stubborn problems of power and resistance find an answer in IRC resistors. Where crowded chassis demand miniaturization—where portable units call for maximum lightness—where critical applications require complete insulation, unusual heat dissipation, or ability to handle exceptionally high voltages—there's an IRC power resistor for the specific job. Manufacturing the widest line of resistance products in the industry, IRC can specify *without bias!* This is your warranty of efficient, economical resistor performance in virtually any application.

**UNSURPASSED FOR ADAPTABILITY** to an extremely wide variety of design requirements, IRC Type MW Wire Wound Resistors also give more watts per dollar than conventional types. Initial cost and mounting cost are low. Flexibility in providing taps and savings in space suit flat Type MW's to a host of difficult applications. Mounting bracket of unique design actually transfers heat from inside resistor to mounting surface. MW's may be operated at full "on plate" rating, whether enclosed or not, without exceeding their rated temperature of 100° C. (Thus, an MW 5 can be used at 20 watts where a 60 watt tubular resistor would normally be required.) Use the convenient coupon to obtain full characteristic and specification data.

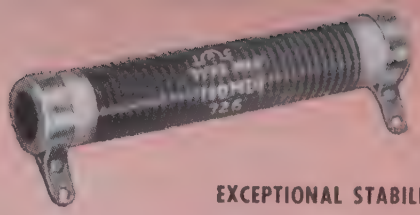


# be tough



**HIGHER SPACE-POWER RATIO** than tubular power resistors makes IRC Type FRW Flat WireWounds ideal for voltage dropping applications in limited space. FRW's can be mounted vertically or horizontally, singly or in stacks—and are available in fixed or adjustable types. Bulletin C-1 gives all the performance facts.

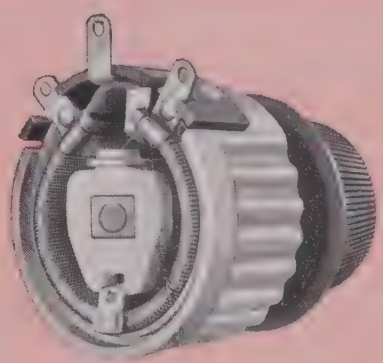
**UNEXCELLED IN EXACTING, HEAVY-DUTY REQUIREMENTS,** IRC Power Wire Wounds are designed to give balanced performance in every characteristic. Special dark, rough coating assures ability to combat humidity and moisture corrosion, dissipate high heat rapidly, withstand reasonable overloads without opens or breakdowns. Available in a broad range of ratings, sizes and terminal styles in fixed and adjustable types. Send for Bulletin C-2.



**EXCEPTIONAL STABILITY**

even in very high resistance values assures the dependability of IRC Type MV Resistors in high voltage applications. Unique application of IRC's famous filament coating in helical turns on a ceramic tube provides a conducting path of long effective length, and permits the use of high voltage on the resistor while keeping the voltage per unit length of path comparatively low. Bulletin G-1 gives complete characteristics; use handy coupon.

| LENGTH OF RESISTANCE PATH IN INCHES—FOR MV TYPES | | | |
|---|---|---|---|
| MVF | 10 | MVS | 20 |
| MVG | 25 | MVT | 30 |
| MVJ | 50 | MVB | 70 |
| MVP | 80 | MVD | 95 |
| MVA | 190 | MVZ | 185 |
| MVO | 330 | MVE | 265 |
| MVR | 1,100 | | |



**VARIABLE POWER** requirements within 25 and 50 watt ratings are well handled by IRC Type PR Power Rheostats. All-metal corrugated construction gives maximum heat dissipation. PR Rheostats can be operated at full power in as little as 25% of rotation without appreciable temperature rise. Direct contact between housing and mounting panel increases ability to disperse heat. Bulletin E-2 details specifications; send for your copy.

hen you're being "powered" for fast service on nall order resistor requirements for experimental ork, pilot runs, or maintenance, call your nearest RC Distributor. IRC's Industrial Service Plan nables him to save you time and worry by giving ou 'round-the-corner service on standard types ght from his local stocks. He's a handy man to now. May we send you his name and address?

IRC

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*Insulated Composition Resistors*
*Low Wattage Wire Wounds*
*Rheostats • Voltage Dividers*
*Controls • Voltmeter Multipliers*
*Deposited Carbon Precistors*
*HF and High Voltage Resistors*
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Send me additional data on the items checked below:

- ☐ MW Insulated Wire Wounds
- ☐ MV High Voltage Resistors
- ☐ PR Power Rheostats
- ☐ FRW Flat Wire Wounds
- ☐ Power Wire Wounds
- ☐ Name and address of local IRC Distributor

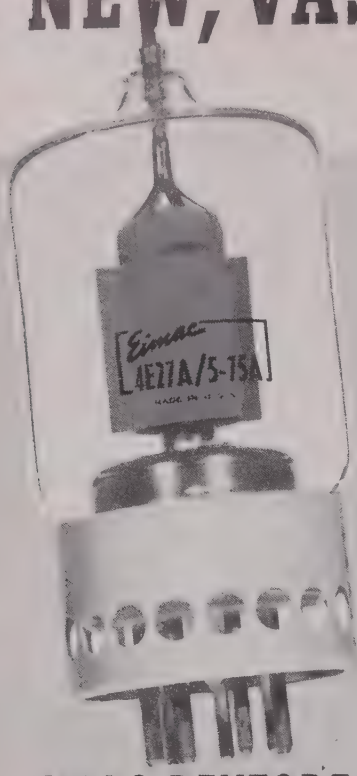
NAME .....

TITLE .....

COMPANY .....

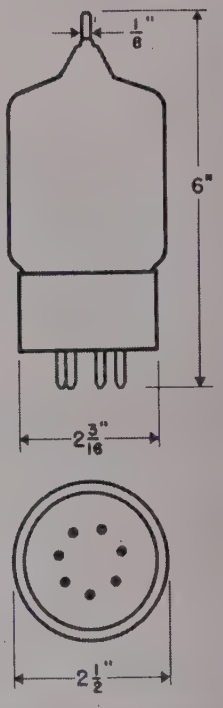
ADDRESS .....

# A NEW, VASTLY IMPROVED 4E27




## EIMAC PENTODE TYPE 4E27A/5-75A

- MORE RUGGED PLATE-LEAD
- PYROVAC PLATE
- OVERSIZE PLATE
- NON-EMITTING GRIDS
- MECHANICALLY RUGGED
- MOULDED-GLASS HEADER
- LOW-LOSS LEADS
- EASILY COOLED STEM




Encompassed in the structure of this new version of the 4E27 are many outstanding improvements that now will guarantee performance-dependability to users of this tube type.

The plate-lead of this new Eimac 4E27A/5-75A pentode is of larger diameter than the protype* providing a low-loss, low inductance, more rugged lead. The plate itself is larger assuring a good reserve dissipation capacity above its 75 watt rating. It is made of Eimac Pyrovac plate material, which lengthens the life of the tube and enables it to withstand high momentary overloads.

Primary grid emission has been eliminated and secondary characteristics stabilized through the use of Eimac processed grids. Perfected beam-action and permanent alignment are assured through well engineered internal-element mounts.

The unique moulded-glass header eliminates a base on the 4E27A/5-75A. This simplifies lead cooling, minimizes lead losses, and provides precision alignment of base-pins.

The stability and high power-gain characteristics of this new Eimac pentode make it an excellent VHF or video power amplifier. It is equally well suited for conventional power amplifier service.

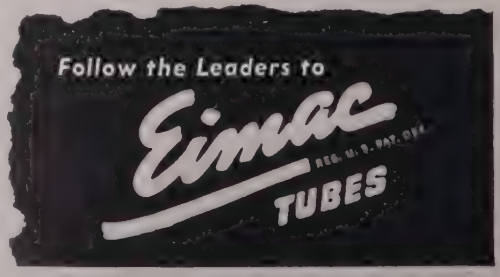
Further information and detailed characteristics concerning this latest product of Eimac engineering research may be had by writing the Application Engineering Department of Eitel-McCullough, Inc.

* Lead connector is supplied to make this new tube directly interchangeable with 4E27.

236

EITEL-McCULLOUGH, INC.
San Bruno, California

EXPORT AGENTS: FRAZAR & HANSEN 301 CLAY ST., SAN FRANCISCO 11, CALIFORNIA



# Specify Hi-Q COMPONENTS-

## BPD's (Disks) and BPF's (Flats)

## for SPACE SAVING and ECONOMY

ILLUSTRATIONS APPROXIMATELY ACTUAL SIZE

**Hi-Q** Disk and **Hi-Q** Flat Ceramic Capacitors frequently save space simply because their physical shape is more adaptable than tubular units . . . *and even more frequently* because one of them serves in place of two, three or more individual capacitors. The multiple units also simplify soldering and wiring operations and thus effect substantial production economies.

These are just a few of the many types of **Hi-Q** Components which are setting the highest possible standards for *Precision*, *Quality*, *Uniformity* and *Miniaturization*. Our engineers are always available to work with you in developing capacitors or combinations of capacitors to best meet your specific needs. Please feel free to call on us at any time.

- **Hi-Q** BPD's (Disks) are available in capacities of from .001 mf. to .01 mf. Dual units range from 2x.001 mf. to 2x.005 mf. Triple units are supplied in standard rating of 3x.0015 mf. and 3x.002 mf. All are guaranteed minimum values.
- **Hi-Q** BPF's (Flats) can be produced in an unlimited range of capacities. The number of capacities on a plate is limited only by the "K" of the material and the physical size of the unit. They do *not* necessarily have to have a common ground as is the case with the disk type.

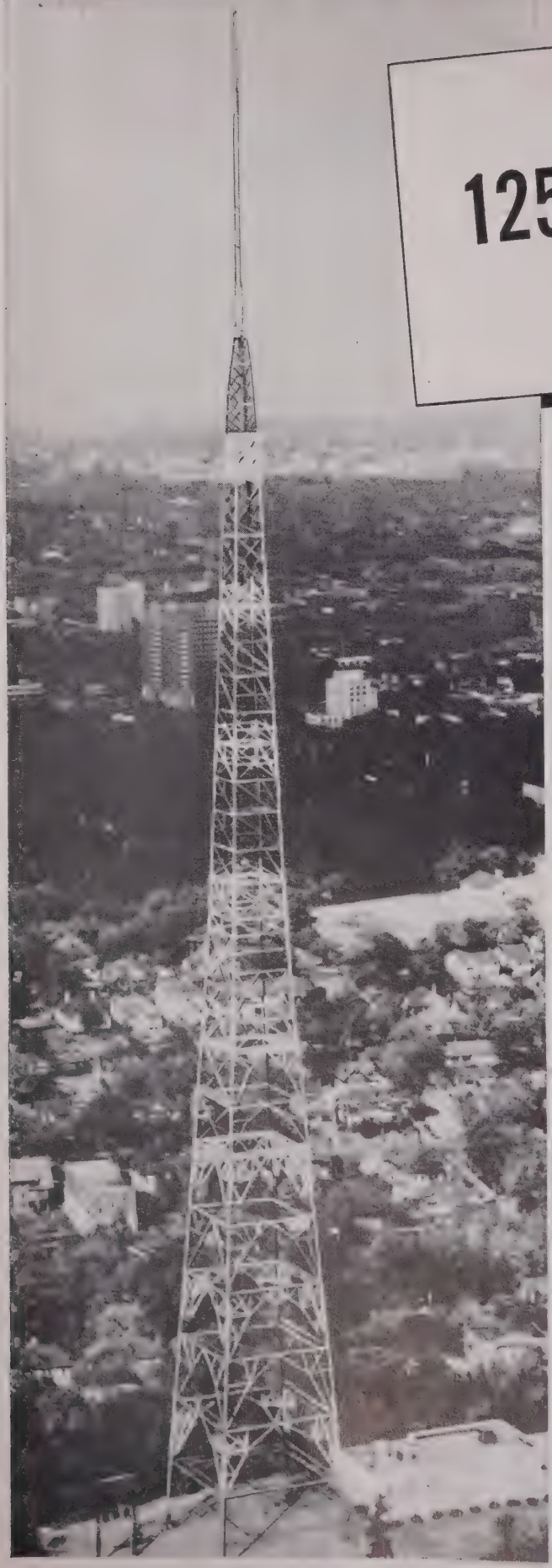
Jobbers—Address Room 1332
101 Park Ave. New York, N.Y.

**Hi-Q** *Electrical Reactance Corp.*

FRANKLINVILLE, N. Y.

*Plants:* Franklinville, N.Y.— Jessup, Pa.— Myrtle Beach, S. C.

*Sales Offices:* New York, Philadelphia, Detroit, Chicago, Los Angeles



# A 125,000 SQ. MILE BLANKET!

The most powerful FM installation in the world recently completed on Red Mountain near Birmingham, Alabama for Station WBRC-FM brings static-free entertainment to residents in a transmission radius of 200 miles.

Important to this installation is the 450 ft. Blaw-Knox type N-28 heavy-duty tower supporting the 8-section Pylon FM antenna. Sturdy, safe and backed by the many years of Blaw-Knox design and engineering in the radio field, it will enable this great new FM Voice of the South to utilize the full capacity of its modern facilities.

**BLAW-KNOX DIVISION of Blaw-Knox Company**
**2037 Farmers Bank Building, Pittsburgh 22, Pa.**

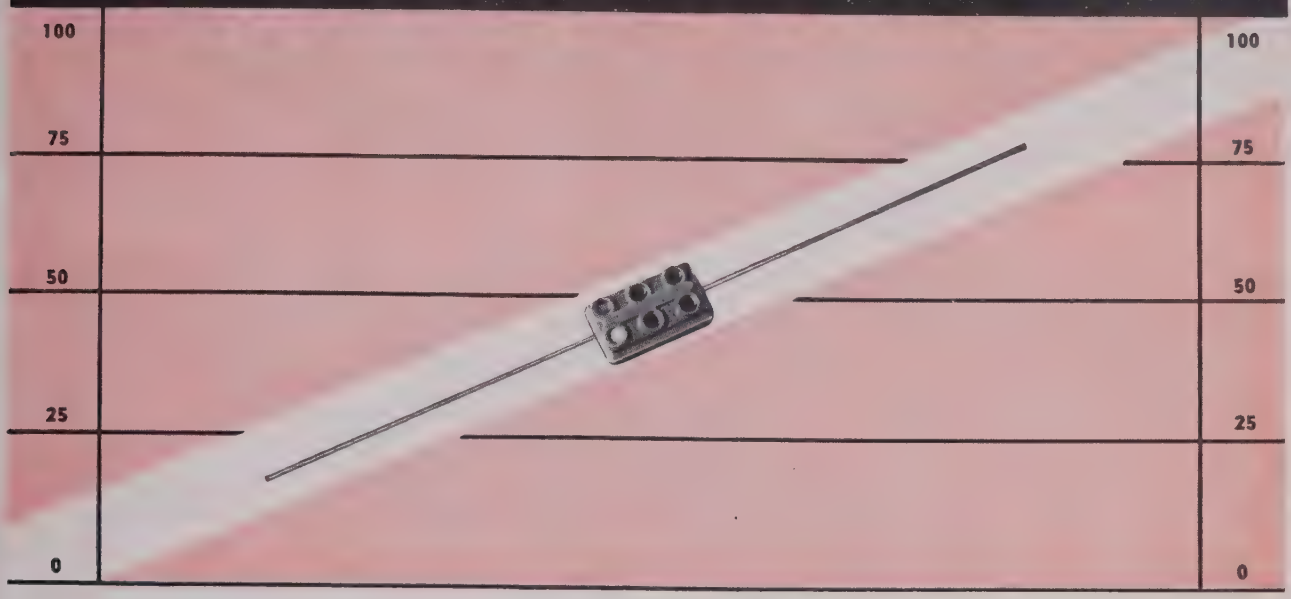
BLAW KNOX

ANTENNA TOWERS

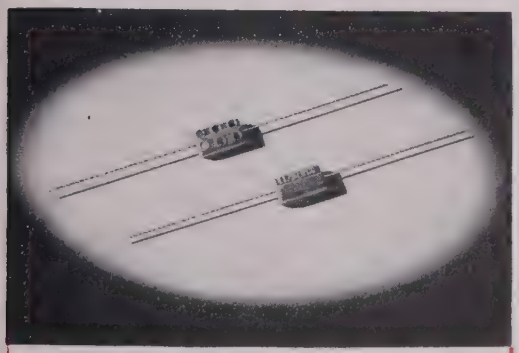
Distributed by GraybaR
OFFICES IN 100 PRINCIPAL CITIES

# BLAW-KNOX
## ANTENNA TOWERS

# For Peak Performance...




## EL-MENCO CAPACITORS



**CM 15**

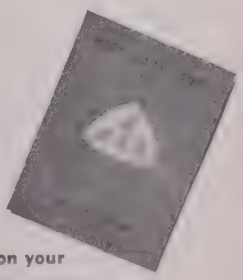
Actual Size 9/32" x ½" x 3/16".
For Television, Radio and other Electronic Applications.
2 — 420 mmf. cap. at 500v DCw.
2 — 525 mmf. cap. at 300v DCw.
Temp. Co-efficient ±50 parts per million per degree C for most capacity values.
6-dot color coded.

You can always depend on these tiny but tried and trusted El-Menco capacitors to give peak performance for long periods of time under the most exacting conditions. Rigid test during and after manufacture insures uniformity and assures quality.

Performance proved, these fixed mica dielectric capacitors are specified by nationally-known manufacturers.

*When you need peak performance in capacitors, get the best — get* **El-Menco.**

**THE ELECTRO MOTIVE MFG. CO., Inc.**
WILLIMANTIC CONNECTICUT



Write on your firm letterhead for Catalog and Samples

MOLDED MICA **El-Menco** MICA TRIMMER
CAPACITORS

FOREIGN RADIO AND ELECTRONIC MANUFACTURERS COMMUNICATE DIRECT WITH OUR EXPORT DEPT. AT WILLIMANTIC, CONN. FOR INFORMATION.

ARCO ELECTRONICS, INC. 135 Liberty St., New York, N. Y.—Sole Agent for Jobbers and Distributors in U.S. and Canada

ELECTRONICS

# Designers

## A LINE-VOLTAGE STABILIZER

**SO SMALL . . .**

*. . . it mounts on a radio chassis*

These 15-, 25-, and 50-va G-E voltage-stabilizer units are only a little over 2 inches high and about 9 inches long. They'll mount easily on a medium-sized radio or electronic instrument chassis and will give you an even, non-fluctuating 115 volts for your equipment whether your line voltage is 95 or 130. A special transformer circuit provides a stabilized output voltage within 1% of 115 volts for fixed, unity-power-factor loads.

Continuous operation under conditions of short or open circuits will not damage the stabilizer in any way. Since there are no moving parts, there is little maintenance to worry about. For complete information on voltage-stabilizer units of all sizes from 15-va to 5000-va, write for Bulletin GEA-3634.

## AN EASY WAY TO PRODUCE SQUARE WAVES

Specially designed G-E Type-E networks will produce impulses which have definite, known energy contents and durations, and thus are ideal for converting a-c or d-c charging voltages into approximately rectangular square waves. These networks consist of capacitor and coil sections adjusted to close tolerances and hermetically sealed in single metal containers.

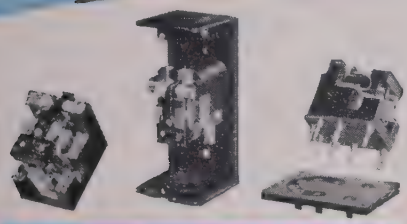
G.E. helped meet wartime radar demands with thousands of these units and now offers them for commercial use. They are available in a wide range of designs, impedances, ratings, and sizes for pulse lengths of 0.1 to 40 microseconds. See Bulletin GEA-4996.

GENERAL ELECTRIC

667-3

# Digest

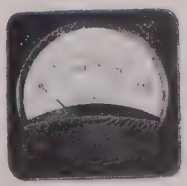
# TIMELY HIGHLIGHTS ON G-E COMPONENTS



## HEAVY-DUTY RELAYS THAT MOUNT 3 WAYS

This versatile, general-purpose, heavy-duty, a-c relay unit is available in three mounting arrangements: front connected, back connected, or plug-in connected. All three mounting types are available in open or enclosed models and are furnished in spst, dpst, or dpdt circuits. Heavy, long-lasting silver contacts carry 10 amps continuous. Normally-open forms make or break 45 amps; normally-closed forms make or break 20 amps. Relay coils come in 12-, 24-, 115-, or 230-volt, 60-cycle a-c sizes. D-c units are available in similar models. For full details see GEC-257.

## ACCURATE BUT RUGGED

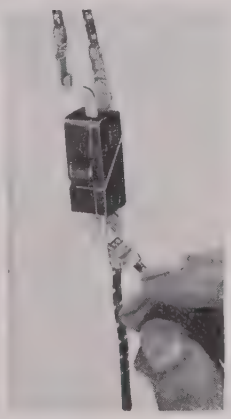


The new, modern-looking, easy-to-read 2½ inch G-E instrument line is improved inside as well as outside. A single, self-contained mechanism supported on an extremely strong Alnico magnet assures permanent alignment even under the most adverse operating conditions. This high-gauss Alnico magnet permits the use of a large air gap with a consequent smoother, non-sticking action. The greater torque-to-weight ratio means better damping and allows the use of heavier vibration-resisting pivots. Accuracy is 5% of full scale on rectifier types, 2% on all others. For complete details, send for Bulletin GEC-368.

## SNAP-SWITCH INSTALLATION TIME CUT TO SECONDS

You'll have a firm electrical connection without the use of solder a few seconds after you begin to install this small but rugged Switchette. Only 1½ inches long and weighing only 9 grams, this 230-vac, 10-amp unit has solderless knife-contact terminals made of pure, tinned copper.

G-E Switchettes are available in a variety of forms and circuits, all of which have double-break contact structures. They're particularly well suited for electronic applications because of their low RF noise output (short contact-bounce).



For your convenience there are screw-terminal and soldering-lug types as well as this special quick-connect unit. Send for Bulletin GEA-4888.

## A SMALL PACKAGE OF WELL-REGULATED HIGH VOLTAGE

You get both high voltage and good regulation with small lightweight G-E precision rectifiers. This may interest you if you need compact, well-regulated, high d-c voltage sources for cathode-ray tubes, television camera tubes, radar indicator scopes, electron microscopes, Geiger-Mueller counters, or similar jobs.

These supplies are hermetically sealed and oil-filled. Typical units have outputs of 7 kv at 0.1 ma.—have only 3.5% deviation for every 0.1 ma load and output ripple of less than 1%. Size—only 6" x 6" x 7". Weight—8 lbs. For further data, write: General Electric Company, Section 667-3, Schenectady 5, N. Y., giving complete information on the proposed application with specifications required.

General Electric Company, Section H 667-3
Apparatus Department, Schenectady, N. Y.

Please send me the following bulletins:

- ☐ GEA-3634 Voltage stabilizers
- ☐ GEA-4888 Switchettes
- ☐ GEA-4996 Capacitor networks
- ☐ GEC-257 Heavy-duty relays
- ☐ GEC-368 Instruments

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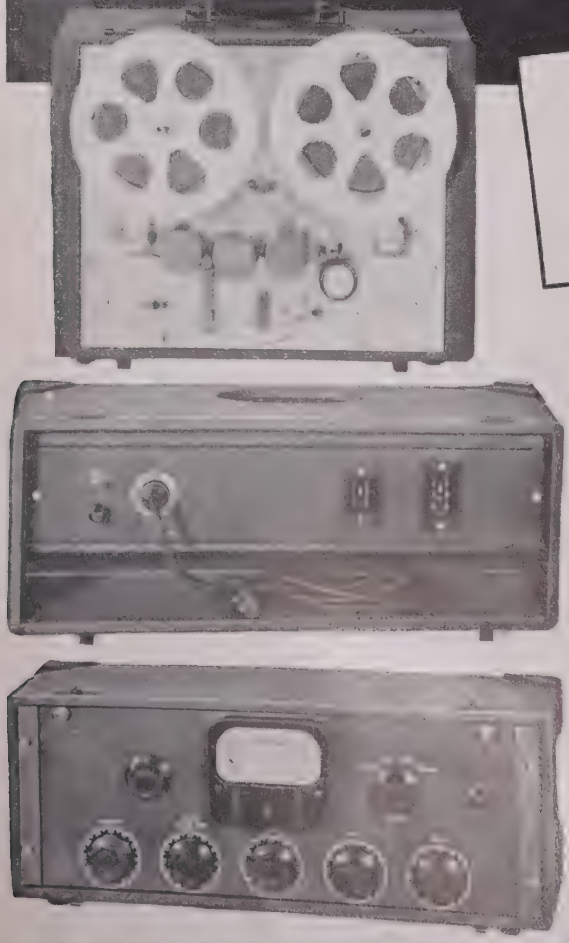
"Top Fidelity...the most dependable Tape Recorder yet!" says WOR's STAN LOMAX



# NEW PRESTO
## PORTABLE TAPE RECORDER

PRESTO'S PT-900 is the answer for delayed sports broadcasts—field recording—wherever there is a need for a portable recorder of complete broadcast quality. Look at these outstanding engineering features:

- **Three separate heads for superior performance (and for monitoring direct from tape). One head each to erase, record and play back.**
- **3 microphone channels with master gain control in recording amplifier.**
- **Large V.U. meter with illuminated dial to indicate recording level, playback output level, bias current and erase current, and level for telephone line.**
- **2-speed, single motor drive system. Toggle switch to change tape speeds from 7½" to 15" per second.**

Don't choose your tape recorder until you see the *new* Presto Portable Tape Recorder. Write for complete details today.

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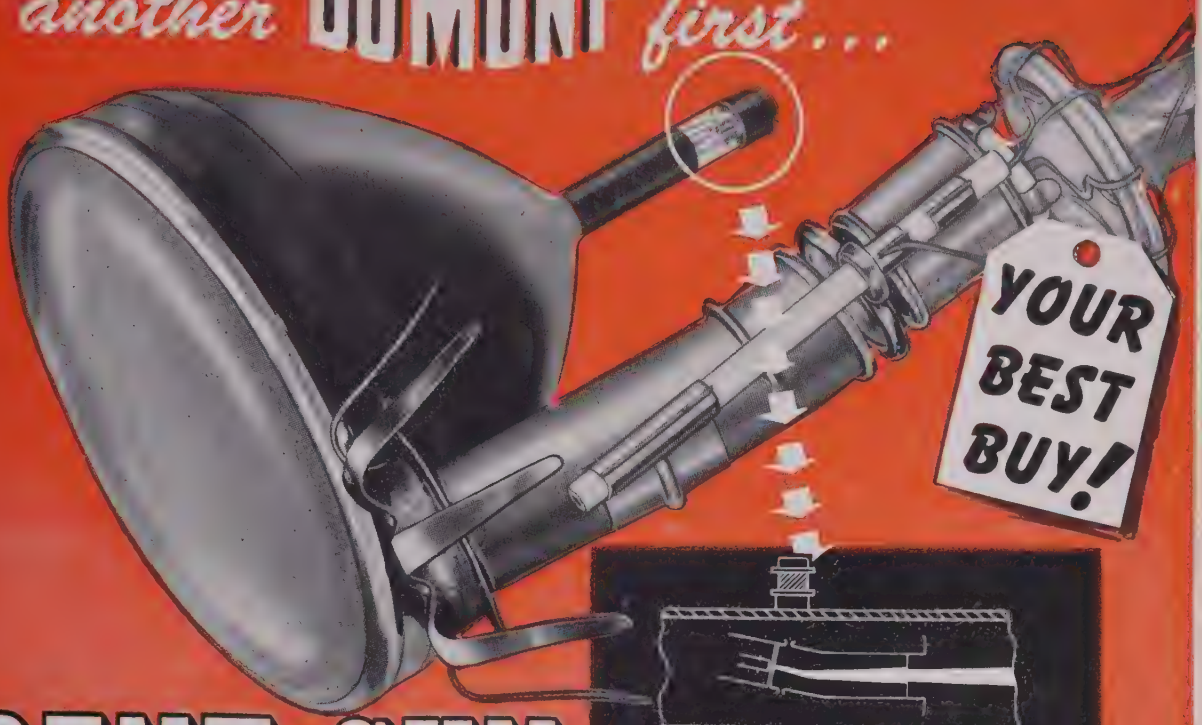
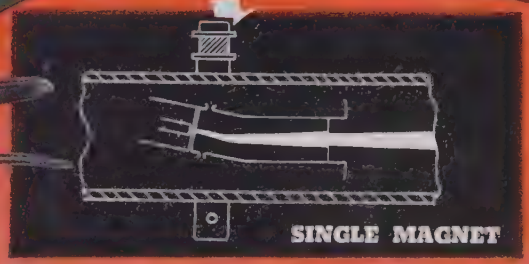
RECORDING CORPORATION
Paramus, New Jersey
*Mailing Address:* P. O. Box 500, Hackensack, N. J.
In Canada: WALTER P. DOWNS, Ltd., Dominion Sq. Bldg., Montreal

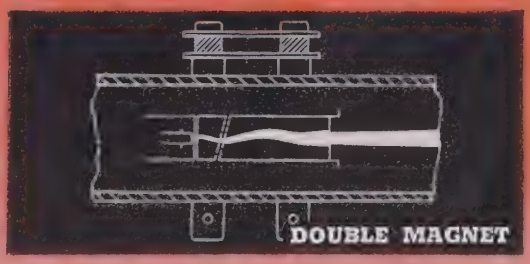
*WORLD'S GREATEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT AND DISCS*

another DUMONT first...




# BENT-GUN Teletrons*




The new Du Mont Types 12RP4 and 15DP4 (replacing respectively Types 12JP4 and 15AP4) feature the exclusive Du Mont bent-gun. This ion-trap design eliminates ion-spot blemishes while maintaining an undistorted spot for maximum pictorial resolution. Meanwhile, lead-free glass reduces tube weight considerably. Five-pin duodecal base permits using the new half-socket for a significant saving, although old-type full-socket also accommodates these new tubes without modification.

Definitely "Your best buy!" For initial-equipment or replacement purposes — for superlative performance and longest service — insist on Du Mont Teletrons!

*Above: Du Mont bent-gun principle, utilizing single ion-trap magnet. Space saved by eliminating double beam-bending magnet results in shorter neck length. Focussed-spot distortion eliminated by use of electrode parts designed to form symmetrical electrostatic fields in $G_3$ space. Lower-cost magnet.*

Below: *Conventional straight-gun design. Ion and electron beam is twisted by slanting electrostatic field between second grid and anode, requiring TWO bending magnetic fields. More costly beam-bender. Longer neck. Focussed-spot distortion.*

**Write for latest literature.**

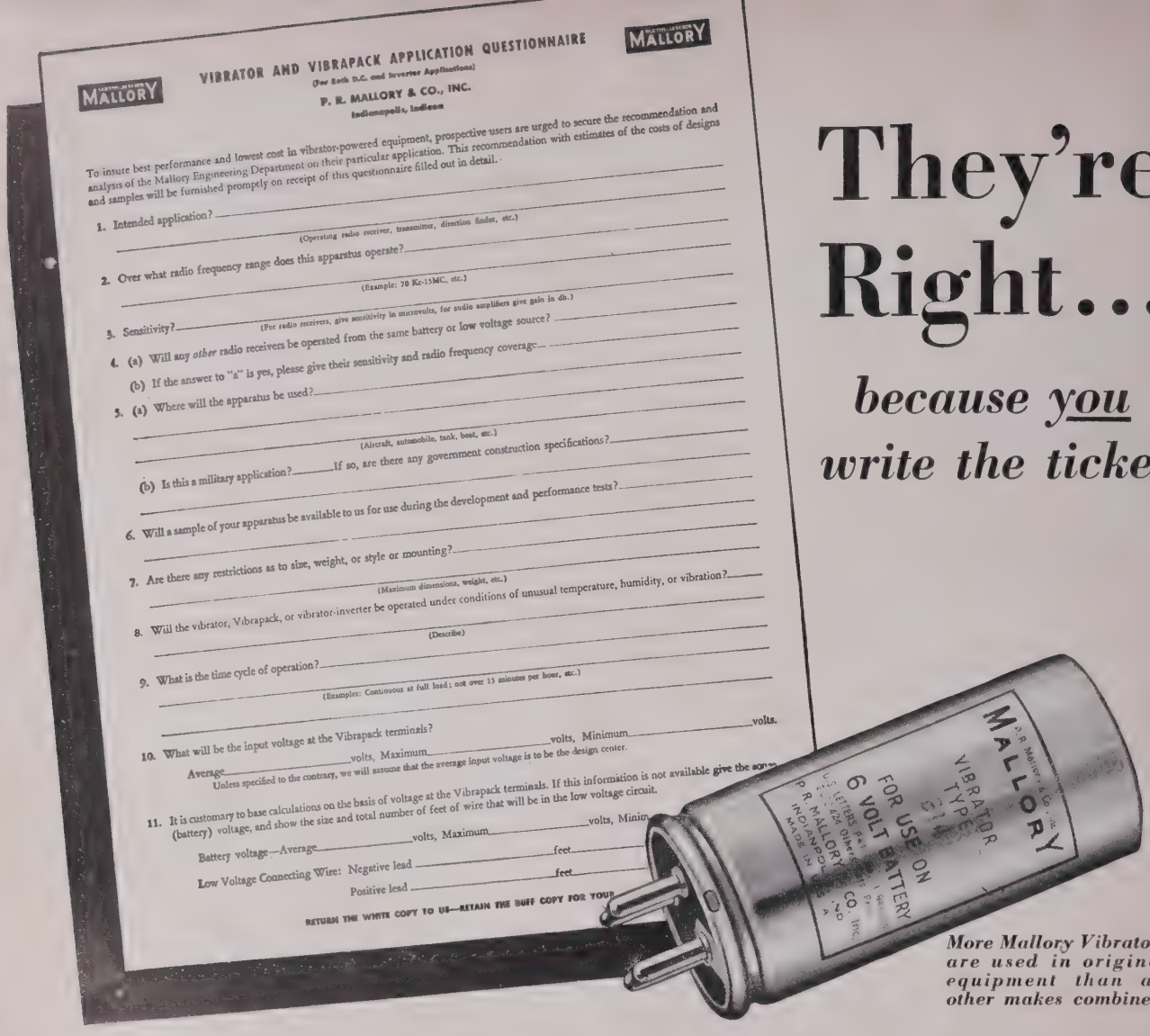
© ALLEN B. DU MONT LABORATORIES, INC.

*TRADE MARK

FIRST WITH THE FINEST IN T-V TUBES

DUMONT Teletrons

ALLEN B. DU MONT LABORATORIES, INC. • TUBE DIVISION • PASSAIC, NEW JERSEY

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## *because you write the ticket*

***More Mallory Vibrators are used in original equipment than all other makes combined.***

Creative research is no empty slogan at Mallory. Mallory Vibrators are the world's most popular simply because engineering skill, long experience and adherence to quality ideals have made them better.

But Mallory engineers know that the finest vibrators can fail because of a power transformer design . . . or a wrong value buffer capacitor. That's why they want to know the whole story of your problem.

That's the reason for the inquisitive questionnaire shown above. It's the reason why so many Mallory Vibrators are right for the job. With this information, Mallory engineers can make *intelligent* and *profitable* recommendations.

Do you have a supply of these "tell-all" questionnaires in your engineering files? If not, we earnestly suggest you give your Mallory representative a call—or write to Mallory direct. Do it now. And remember, too, that standard Mallory Vibrators are quickly available from authorized Mallory distributors.

Vibrators and Vibrapack* Power Supplies

P. R. MALLORY & CO. Inc.

MALLORY

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**SERVING INDUSTRY WITH**

Capacitors — Rectifiers
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Controls — Vibrators
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Resistance Welding Materials

*Reg. U. S. Pat. Off.

# ANNOUNCING...Television's greatest picture tube improvement!

## The New Rauland Luxide Screen

1. Greatly diminishes tube face halation

2. Reduces reflection of ambient light

### New Tube Vastly Increases Contrast!

Here is a scientific advance in picture tube technique which offers a marked, visible picture improvement already widely acclaimed by Television buyers.

In this newest Rauland development, the tube face is a new, practically colorless glass containing a metallic oxide which produces uniform light attenuation throughout the visible range. This light-absorbing characteristic acts in two ways to increase picture contrast, clarity and detail.

In ordinary tubes, light from bright picture areas of the screen striking the exterior tube face surface in angles greater than 48 degrees is completely reflected onto dark screen areas, reducing the apparent blackness. This halation is greatly reduced with the new Rauland "Luxide" screen, because such reflected light is attenuated by passing three times through the glass before it can reach the eye.

Similarly, under normal conditions, clear glass picture tubes can have their maximum contrast only when operated in an otherwise dark room. Ambient light passing through the tube face to the phosphor causes the dark picture area to appear light in tone and causes the picture to "wash out." With the "Luxide" screen, such ambient light must pass twice through the attenuating glass while light originating in the phosphor passes through the glass only once. The result is a picture with far greater contrast when viewed in lighted rooms, and since several more steps in the grey scale are available in forming the picture, better detail as well as greater contrast results.

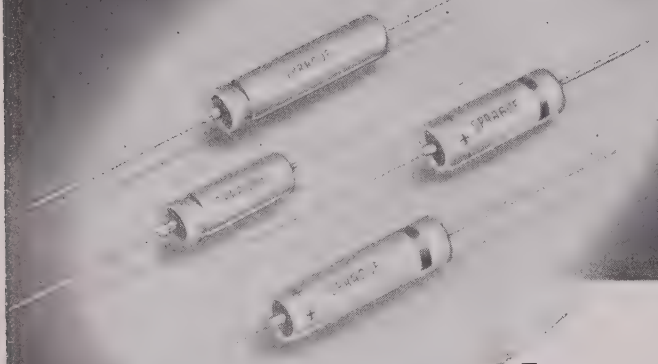
**Write for Technical Bulletins.** The Luxide screen is available in metal-cone types 16AP4-A, 16EP4-A and 12UP4-A, and in the all-glass 12LP4-A.

## THE RAULAND CORPORATION

*Perfection Through Research*

4245 N. KNOX AVENUE · CHICAGO 41, ILLINOIS

# SPACE SAVERS *de luxe*



## SPRAGUE
### MINIATURE
### DRY ELECTROLYTICS
*Types 16D and 18D*

These exceptionally small capacitors really solve space problems in miniaturized electronic and radio equipment. And their performance characteristics actually surpass those of ordinary metal encased tubular dry electrolytic capacitors!

Sealed against moisture, Types 16D and 18D electrolytics are normally furnished for operation at 85° C. to meet the high operating temperatures common in crowded assemblies. Type 18D has an outer insulating tube over the metal case, whereas Type 16D does not have this extra covering.

*Write for Sprague Engineering Bulletin No. 303 for complete details.*

SPRAGUE

PIONEERS IN ELECTRIC AND ELECTRONIC DEVELOPMENT

SPRAGUE ELECTRIC COMPANY
North Adams, Mass.

# grinding

***by skilled operators***

***enables AlSiMag to meet***

***unusual dimensional tolerances***

**AlSiMag**
Reg. U. S. Pat. Off.

After firing, AlSiMag is extremely hard. Further finishing requires special tools, great skill. We have the tools and the skill and can meet almost any tolerance required. The closer tolerances involve commensurate cost. Even if you think your requirements are impossible, ask us. It is probable that we can solve your problem . . . well within practical cost limits. Ability to consistently comply with dimensional and physical requirements is another reason why American Lava Corporation is known as Headquarters for Custom Made Technical Ceramics.

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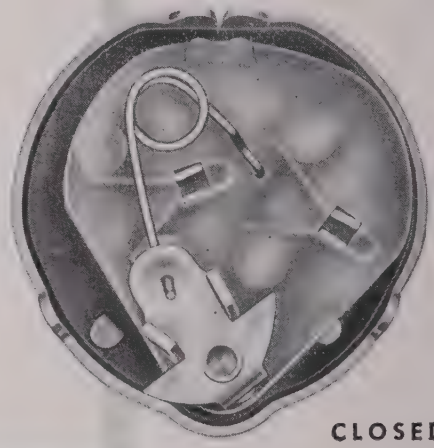
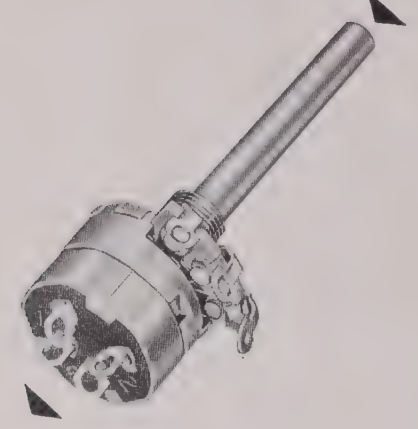
# a simplified, outstandingly dependable LINE SWITCH for Stackpole Controls

OPEN

*(Interior views approximately 2½ times actual size of switch)*



CLOSED



Only .888" in diameter by .312" thick, this Type A-10 double-pole, single-throw line switch fits even the smallest Stackpole controls. Rated 1 ampere at 250 volts AC-DC or 3 amperes at 125 volts AC-DC, it combines outstanding ruggedness of design with ample-sized contacts and positive contact wiping action. Stationary contacts are mounted on a fiber surfaced Bakelite base to reduce arc tracing. The base is held securely in the can. Throughout, the switch is constructed for long, trouble-free service and in suitable ratings for portable and auto radios and numerous other applications. A similar single-pole design (Type A-11) with dummy terminal is also available.

*Write for Stackpole Bulletin RC-7*

ELECTRONIC COMPONENTS DIVISION

STACKPOLE CARBON COMPANY, ST. MARYS, PA.

# STACKPOLE

VARIABLE RESISTORS FOR MODERN RADIO AND TELEVISION NEEDS

# NOW... for the first time

## SUBSTANTIAL POWER

### At Microwave Frequencies with Direct Crystal Control

Now, with two new Sperry Klystron tubes, stabilized frequency control is possible at 10,000 mc. with 1 watt continuous wave power output. These multiplier tubes, the SMC-11 and the SMX-32, permit direct crystal control at microwave frequencies with this power level.

Starting with a 5 mc. crystal, the frequency is multiplied to 830 mc. by use of an *Exciter*. The SMC-11 Klystron multiplies the 830 mc. to a frequency of 5,000 mc. The SMX-32 then multiplies this frequency to 10,000 mc. with the same accuracy which exists in the control crystal ($\pm 0.0005\%$).

**This practical achievement of 1 watt power output with continuous accuracy of frequency control at 10,000 mc. exists only through the use of these two Sperry Klystrons.**

Write our Industrial Department for further information.

SPERRY

**GYROSCOPE COMPANY**

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# INDUSTRIAL ENDURANCE WITH RESEARCH *Quality* . . .

## DU MONT TYPES 250-A and 250-AH

## Cathode-ray Oscillographs

For *research* where utility and precision work demand high-quality performance and steadiest dependability.

In *industry* where a wide range of application and adverse operating conditions demand general-purpose versatility and rugged endurance.

### Equipped for both INDUSTRY and RESEARCH with . . .

Amplification of both a-c and d-c input signals.
Sweep durations as long as 5 seconds.
Recurrent, single, or driven sweeps; spot rests at beginning of forward sweep, virtually eliminating sweep-starting time.
Automatic beam-blanking and provision for intensity modulation.
Photography of oscillograms with either Du Mont Type 271-A or 314-A Oscillograph-record Cameras.
Additional accelerating potential in the Type 250-AH, by using Type 5RP-A Cathode-ray Tube and Type 263-B High Voltage Power Supply Unit.
Projection of Oscillograms with Du Mont Type 2542 Projection Lens.
Built-in Voltage Calibrator.
High-impedance input probe.

***Literature or demonstration on request, without obligation.***

### SPECIFICATIONS . . .

**Cathode-ray Tube:** For Type 250-A, Type 5CP-A; for Type 250-AH, 5RP-A.

**Accelerating Potentials:** Type 250-A, 3200 volts; Type 250-AH, 13,500 volts.

**Y-Axis:** Deflection factor, 0.015 rms volt/in. maximum through amplifier at full gain; 0.15 through probe and amplifier; 0.9 d-c volts maximum through d-c amplifier at full gain; 21 rms volts/in. ±20% direct to deflection plates. Sinusoidal frequency response of a-c amplifiers uniform within 10% from 5 to 200,000 cps; within 60% to 500,000 cps. Response of d-c amplifier uniform within 10% from 0 to 200,000 cps.

**X-Axis:** Deflection factor, 0.4 rms volt/in. maximum through a-c amplifier at full gain; 1.2 d-c volts/in. maximum through d-c amplifier at full gain; 23 rms volts/in. ±20% direct to deflection plates. Sinusoidal frequency response of a-c amplifier uniform within 10% from 5 to 200,000 cps; within 60% to 500,000 cps. Response of d-c amplifier uniform within 10% from 0 to 200,000 cps.

**Linear Time Base:** Both driven and recurrent sweep-time intervals continuously variable from 5 seconds to 10 microseconds.

**Intensity Modulation:** 5 volts peak for adequate modulation.

**Primary Power:** 115/230 volts, 50-60 cycles, 250 watts.

**Dimensions:** 15" h., 11" w., 19" d., *Weight:* 68 lbs.

© ALLEN B. DUMONT LABORATORIES

# DUMONT *for Oscillography*

ALLEN B. DUMONT LABORATORIES, INC., *INSTRUMENT DIVISION*, 1000 MAIN AVENUE, CLIFTON, NEW JERSEY

# GENERAL ELECTRIC CUSTOM MINIATURES ON THE JOB FOR AVIATION— STANDING BY TO WORK FOR YOU!

RELIABILITY is the one big feature common to the four tubes shown here. First of a growing family of General Electric miniatures designed and built to order for specific jobs, these tubes now are at work for commercial airlines in altimeters, radio compasses, radio control equipment, and high-frequency aircraft radio receivers.

Each tube receives 50 hours of operation under Class A conditions. As an added control, samples regularly are selected and subjected to a life test in which the tube is operated normally but intermittently by turning the heaters on and off at one-minute intervals. These unusually exacting tests are made to avoid early life failures, and to assure that tube performance will be in line with ratings consistently.

Aviation is but one of many industries to which G-E Custom Miniatures are adapted, and for which General Electric special design and production facilities are available. Why not use these tubes for superior performance in *your* next design? Wire or write *General Electric Company, Electronics Department, Schenectady 5, New York.*

## CHARACTERISTICS

### TYPE GL-5814

| | |
|---|---|
| Heater voltage, a-c or d-c series | 12.6 v |
| Heater current | 0.175 amp |
| or | |
| Heater voltage a-c or d-c parallel | 6.3 v |
| Heater current | 0.350 amp |
| *Max ratings, design center values, each triode section:* | |
| plate voltage | 300 v |
| plate dissipation | 2.75 w |
| *Typical operation, each section:* | |
| plate voltage | 250 v |
| grid-bias voltage | −8.5 v |
| amplification factor | 17 |
| plate resistance | 7,700 ohms |
| transconductance | 2,200 micromhos |
| plate current | 10.5 ma |

### TYPE GL-5751

| | |
|---|---|
| Heater voltage, a-c or d-c series | 12.6 v |
| Heater current | 0.175 amp |
| or | |
| Heater voltage, a-c or d-c parallel | 6.3 v |
| Heater current | 0.350 amp |
| *Max ratings, design center values, each triode section:* | |
| plate voltage | 300 v |
| grid-bias voltage | never positive |
| plate dissipation | 1.0 w |
| *Typical operation, each section:* | |
| plate voltage | 250 v |
| grid-bias voltage | −3 v |
| amplification factor | 70 |
| plate resistance | 58,000 ohms |
| transconductance | 1,200 micromhos |
| plate current | 1.1 ma |

### TYPE GL-5670

| | |
|---|---|
| Heater voltage, a-c or d-c | 6.3 v |
| Heater current | 0.350 amp |
| *Max ratings, design center values, each triode section:* | |
| plate voltage | 300 v |
| plate dissipation | 1.5 w |
| *Typical operation, Class A1:* | |
| plate voltage | 150 v |
| cathode resistor, per section | 240 ohms |
| plate current, per section | 8.2 ma |
| transconductance, per section | 5,550 micromhos |
| amplification factor | 35 |

### TYPE GL-5654

| | |
|---|---|
| Heater voltage, a-c or d-c | 6.3 v |
| Heater current | 0.175 amp |
| *Max ratings, design center values:* | |
| plate voltage | 180 v |
| grid No. 2 voltage | 140 v |
| plate dissipation | 1.7 w |
| grid No. 2 dissipation | 0.5 w |
| *Typical operation:* | |
| plate voltage | 120 v |
| grid No. 2 voltage | 120 v |
| cathode-bias resistor | 200 ohms |
| plate resistance (approx) | 0.34 megohms |
| transconductance | 5,000 micromhos |
| plate current | 7.5 ma |
| grid No. 2 current | 2.5 ma |

GENERAL ELECTRIC

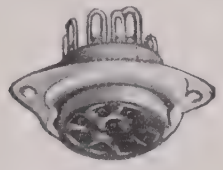
FIRST AND GREATEST NAME IN ELECTRONICS

# NEWS and NEW PRODUCTS

DECEMBER, 1949

## Miniature Sockets in Mycalex

A new organization, **Mycalex Tube Socket Corporation,** operating under exclusive license of Mycalex Corporation of America have started the manufacture of 7 pin miniature tube sockets, utilizing precision molded Mycalex as an insulator. The sockets are obtainable in Mycalex 410 which was developed for applications requiring close dimensional tolerances not possible in ceramics and at much lower loss factor than mica filled phenolic with advantage in economy, the manufacturer claims; and in Mycalex 410X which has been developed to compare favorably with general purpose bakelite in economy but with a loss factor of only about one-fourth of that material



Illustrated are two views in actual size of the 7 prong socket. Sockets with different numbers of prongs are in the development stage.

These sockets are manufactured to precise specifications and fully meet RMA standards. Further information is obtainable from **Mycalex Tube Socket Corporation,** 30 Rockefeller Plaza, New York 20, N. Y.

## New Low-Priced Oscillograph

A new low-priced, lightweight oscillograph especially designed for use in schools, colleges, and industrial laboratories has been announced by **General Electric Co., Meter and Instrument Div.,** Schenectady 5, N. Y.

Compact and simple in design, the Type PM-18 instrument is said to be easily operable by inexperienced personnel in the laboratory, or in the field. It can be used either for visual indications, or for taking oscillograms of current and voltage phenomena.

Additional information is contained in Bulletin GEC-580 which is available by writing to the company.

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

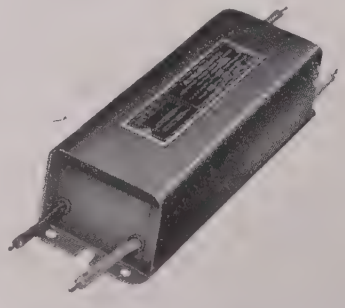
## Prodelin Transmission Line

A new 51.5-ohm air-dielectric coaxial transmission line (rigid) with center conductor impedance equivalent to that of air, for use in any given position of the spectrum up through the microwave frequencies, is available from the manufacturer, **Product Development Co. Inc.,** 526 Elm St., Arlington, N. J.

Physical properties of a new press-fit construction provide a line with accurate physical tolerances that will withstand high-impact shock or exposure to rapid temperature changes. A threaded self-sealing coupling has also been developed for use at frequencies where a minimum VSWR is required.

## New 75-Watt Lamp Ballast

A new lamp ballast has been developed by the engineering department of **Acme Electric Corp.,** 44 Water St., Cuba, N. Y. for use with the new 75-watt, 96-inch T-12 slim-line lamp.



The manufacturer claims that this ballast provides an output of 75 watts, 0.425 amperes, a minimum of 700 volts starting and 195 volts operating. With these electrical characteristics the lamp can be expected to operate with a 4,800-lumen output after 100 hours, and an average brightness of 1,600 foot lamberts. This represents an average of 64 lumens per watt.

## New Standard Signal Generator

**Measurements Corp.,** Boonton, N. J., have announced the production of a new standard signal generator covering the wide frequency range of 20 cps to 50 Mc.

This instrument, the Model 82, was designed to provide in one signal generator a continuously variable signal source for most measurements at audio, supersonic, and radio frequencies. Two oscillators are employed to cover the frequency range. The low frequency oscillator, continuously variable from 20 cps to 200 kc, has a metered output from 0 to 50 volts across a resistance of 7,500 ohms. A radio-frequency oscillator covering the range from 80 kc to 50 Mc provides output from 0.1-microvolt to 1 volt, and may be modulated with the low-frequency oscillator.

An improved mutual-inductance type attenuator is said to insure a higher degree of accuracy than may be obtained with the resistor or mutual-inductance type attenuator of earlier design.

## Recent Catalogs

• • • An illustrated brochure describing the greatly expanded facilities of The Franklin Institute Research and Development Laboratories may be obtained by writing to **Administration Div., The Franklin Institute Laboratories,** Benjamin Franklin Pkwy., at 20th St., Philadelphia 3, Pa.

• • • The sixth edition of "Johnson Antenna Handbook" was recently published by the **E. F. Johnson Co.,** Waseca, Minn., and is now available from Johnson Jobbers at 60 cents a copy.

• • • Just released by **Triad Transformer Mfg. Co.,** 2254 Sepulveda Blvd., Los Angeles 64, Calif., a 16-page catalog, TR-49, describing and pricing the entire line of Triad transformers for original equipment, radio and television replacement, and amateur applications.

*(Continued on page 61A)*

*New!*

ACCURATE! CONVENIENT!

PORTABLE!

# UHF SIGNAL GENERATOR

***Covers the Range of 400–1000 MC.***

* * * The LAVOIE LA-418 Signal Generator, newest addition to the LAVOIE LABORATORIES' line of precision electronic equipment...

Provides:

- ☆ DIRECT READING Frequency Dial.
- ☆ DIRECT READING Attenuator calibrated in D B (0 TO -120 DBM) U Volts.
- ☆ INTERNAL and EXTERNAL Pulse Modulation sine wave modulation external.

A complete descriptive folder is available promptly on request.

WRITE FOR TECHNICAL BULLETIN LA-418

*Lavoie Laboratories*

RADIO ENGINEERS AND MANUFACTURERS

MORGANVILLE, N. J.

**Specialists in the Development and Manufacture of UHF Equipment**

# WHY STAND ON YOUR HEAD?

1 FACTORY = 1 SOURCE

1 NEDA DISTRIBUTOR = 100 FACTORIES

WHY chase around the countryside, from factory to factory, looking for this or that odd electronics part, when your NEDA Distributor carries the *diversified* supplies you need?

Why lose valuable time, scheduling a pilot run, when your NEDA Distributor has the quantities you need in stock?

Why stand on your head, trying to explain what you want, when your NEDA Distributor understands your specifications and gives you intelligent cooperation, on all your electronics needs?

On the industrial front, more and more engineers and purchasing agents are doing business with the NEDA Distributor . . . because he expedites your purchase of radio and electronics parts with *greater selection . . . faster delivery . . .* and *on-the-spot consultation and service.*

**FOR EXAMPLE:**
**NEDA Distributors Carry**

- Square-wave Generators
- Master Music Systems
- Cathode Ray Tubes
- Electron Multipliers
- Audio Oscillators
- Multiwire Cable
- Terminal Blocks
- Television Parts
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- Communicators
- Power Supplies
- Voltohmmeters
- Potentiometers
- Oscillographs
- Transformers
- Microphones
- Condensers
- Thyratrons
- Amplifiers
- Photocells
- Recorders
- Rheostats
- Cabinets
- Resistors
- Chassis

NATIONAL ELECTRONIC DISTRIBUTORS ASSOCIATION
INCORPORATED
221 [illegible] WACKER BUILDING, 221 N. LaSALLE ST., CHICAGO 1, ILLINOIS

*Consult the list of NEDA members on the opposite page.*

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*TUSCALOOSA*
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Radio Parts of Arizona

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*LITTLE ROCK*
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David White
Radio Supply Co.
*TEXARKANA*
Lavender Radio Supply Co.

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*NEW BRITAIN*
United Radio Supply
*NEW HAVEN*
Hatry & Young
Thomas H. Brown Co.
*NEW LONDON*
Hatry & Young
*STAMFORD*
Hatry & Young
*WATERBURY*
Hatry & Young
The Bond Radio Supply

### DISTRICT OF COLUMBIA
*WASHINGTON*
Electronic Wholesalers, Inc.
Kenyon Radio Supply Co.
Rucker Radio Wholesalers
Silberne Radio & Elec. Co.

### FLORIDA
*MIAMI*
Herman Radio Supply Co.
Walder Radio & Appliance

### GEORGIA
*AUGUSTA*
Prestwood Electronics Co.
*COLUMBUS*
Radio Sales & Service Co.

### IDAHO
*BOISE*
Craddock's Radio Supply
Kopke Electronics Co.

### ILLINOIS
*BELLEVILLE*
Lurtz Electric Co.
*BLOOMINGTON*
Alverson Sales Co.
*CHICAGO*
Allied Radio Corp.
J. G. Bowman & Co.
Chauncey's, Inc.
The Lukko Sales Corp.
Pilgrim Distributing Co.
Radio Parts Co.
Walker-Jimieson, Inc.
*MOLINE*
Lofgren Distributing Co.
*PEORIA*
Herberger Radio Supply
*ROCK ISLAND*
Tri-City Radio Supply
*SPRINGFIELD*
Wilson Supply Co.

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Hub Appliance & Supply Co.
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Pembleton Laboratories
*INDIANAPOLIS*
Van Sickle Radio Supply Co.
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*FORT DODGE*
Ken-Els Radio Supply Co.
*SIOUX CITY*
Duke's Radio Co.
*WATERLOO*
Ray-Mac Radio Supply

### KANSAS
*TOPEKA*
The Overton Electric Co.
*WICHITA*
Excel Distributors
Interstate Distributors, Inc.

### KENTUCKY
*LEXINGTON*
Radio Equipment Co.
*LOUISVILLE*
Peerless Electronic Equipment Co.
Universal Radio Supply Co.
*OWENSBORO*
Central Electronic Supply Co., Inc.

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Central Radio Supply
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Radio Electronic Supply
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F. H. Schneider & Sons
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Hale & McNeil
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Shuler Supply Co.
Southern Radio Supply Co.
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### MAINE
*AUBURN*
Radio Supply Co., Inc.
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### MARYLAND
*BALTIMORE*
Kann-Ellert Electronics, Inc.
Radio Electric Service Co.
Wholesale Radio Parts
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Ware Radio Supply Co.
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Electrical Supply Corp.
*LAWRENCE*
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*MELROSE*
Joe's Radio Shop
Melrose Sales Co.
*NATICK*
Willett Radio Supply, Inc.
*NEW BEDFORD*
C. E. Beckman Co.
*PITTSFIELD*
Pittsfield Radio Co.
*ROXBURY*
Gerber Radio Supply Co.
*SPRINGFIELD*
Hatry & Young
T. F. Cushing
Springfield Radio Co., Inc.
Springfield Sound Co.
*WORCESTER*
Radio Electronic Sales Co.
Radio Maintenance Supply

### MICHIGAN
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*BATTLE CREEK*
Electronic Supply Corp.
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K-L-A Laboratories of Detroit
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Radio Tube Merchandising
Shand Radio Specialties
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*MINNEAPOLIS*
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Lew Bonn Co.
Northwest Radio & Electronic Supply Co.
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Manhattan Radio & Equipment, Inc.
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Radonics
Van Sickle Radio Co.
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Harry Reed Radio & Supply

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Leuck Radio Supply Co.
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J B Distributing Co.
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### NEW HAMPSHIRE
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Evans Radio
*DOVER*
American Radio Corp.
*MANCHESTER*
Radio Service Laboratory

### NEW JERSEY
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Krich-Radisco, Inc.
Aaron Lippman & Co.
*PHILLIPSBURG*
Carl B. Williams Co.

### NEW YORK
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Fort Orange Radio Distributing Co.
E. E. Taylor Co.
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Adirondack Radio Supply
*AUBURN*
Dare's Radio Service
*BINGHAMTON*
Federal Radio Supply Co.
*BROOKLYN*
Green Radio Distributors
National Radio Parts Distributing Co.
*BUFFALO*
Dymac, Inc.
Genesee Radio & Parts Co.
*ELMIRA*
Fred C. Harrison
*GLEN FALLS*
Ray Distributing Co.
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Davis Electronics Corp.
Standard Parts Corp.
*ITHACA*
Stallman of Ithaca
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Norman Radio Distrs., Inc.
*KINGSTON*
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Davis Radio Distributing Co.
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H. L. Dalis, Inc.
Federated Purchaser, Inc.
Fischer Distributing Co., Inc.
Milo Radio & Electronics
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O & W Radio Co.
Powell Radio Supply
Sanford Electronics Corp.
Slate & Co.
Stan-Burn Radio & Electronics Co.
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Terminal Radio Corp.
United Radio & Electric Co.
Wilco Radio Distributors
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Chief Electronics
*ROCHESTER*
Rochester Radio Supply Co.
*SCHENECTADY*
Electric City Radio Supply
*SYRACUSE*
Roberts & O'Brien
Stewart W. Smith, Inc.
*TROY*
Trojan Radio Co., Inc.
*UTICA*
Beacon Electronics, Inc.
Electronic Laboratories & Supply Co.
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### NORTH CAROLINA
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*CHARLOTTE*
Radiotronic Distr., Inc.
*GREENSBORO*
Johannesen Electric Co., Inc.
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*ASHTABULA*
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United Radio, Inc.
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Winteradio, Inc.
*COLUMBUS*
Electronic Supply Co.
Hughes-Peters, Inc.
Thompson Radio Supplies
Whitehead Radio Co.
*DAYTON*
Hughes-Peters, Inc.
Srepco, Inc.
*LIMA*
Lima Radio Parts Co.
*TOLEDO*
Toledo Radio Specialties
Warren Radio Co.
*YOUNGSTOWN*
Ross Radio Co.

### OKLAHOMA
*OKLAHOMA CITY*
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Radio Supply, Inc.
*TULSA*
Patterson Radio Supply Co.
Radio, Inc.
S & S Radio Supply

### OREGON
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*MEDFORD*
Verl G. Walker Co.
*PORTLAND*
Appliance Wholesalers
Bargelt Supply
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Stubbs Electric Co.
Tracey & Co., Inc.
United Radio Supply, Inc.

### PENNSYLVANIA
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*BETHLEHEM*
Buss Electric Supply
*ERIE*
J. V. Duncombe Co.
Jordan Electronic Co.
Warren Radio, Inc.
*HARRISBURG*
Radio Distributing Co.
*JOHNSTOWN*
Cambria Equipment Co.
*PHILADELPHIA*
A. C. Radio Supply Co.
Allied Electric Appliance Parts, Inc.
Almo Radio Co.
Barnett Brothers Radio Co.
Consolidated Radio Co.
Emerson Radio of Pa., Inc.
Herbach & Rademan, Inc.
Nat Lazar Radio Co.
M & H Sporting Goods Co.
Radio Electric Service Co. of Pa., Inc.
Raymond Rosen & Co.
Albert Steinberg & Co.
Eugene G. Wile
*PITTSBURGH*
Cameradio Co.
John Marshall Co.
Radio Parts Co.
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### SOUTH CAROLINA
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Warren Radio Supply
*WATERTOWN*
Burghardt Radio Supply

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*CHATTANOOGA*
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L. K. Rush Co.
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Chemcity Radio & Electric
Roden Electrical Supply Co.
*MEMPHIS*
Bluff City Distr. Co., Inc.
Boyd Electronic Supply
*NASHVILLE*
Electra Distributing Co.

### TEXAS
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*AMARILLO*
R & R Electronic Co.
West Texas Radio Supply
*AUSTIN*
The Hargis Co.
*BEAUMONT*
Montague Radio Distr. Co.
*CORPUS CHRISTI*
Electronic Equipment & Eng. Co.
Wicks-DeVilbiss Co.
*DALLAS*
All-State Distributing Co.
Crabtree's Wholesale Radio
Ra-Tel, Inc.
Wilkinson Brothers
*DENISON*
Denison Radio Supply
*FORT WORTH*
Electronic Equipment Co.
Fort Worth Radio Supply Co.
"Scooter's" Radio Supply
Bill Sutton's Wholesale Electronics
*HOUSTON*
R. C. & L. F. Hall, Inc.
Sterling Radio Products Co.
*LUBBOCK*
R. & R. Supply Co., Inc.
*SAN ANTONIO*
Mission Radio, Inc.
*WACO*
The Hargis Co., Inc.
*WICHITA FALLS*
Clark & Gose Radio Supply
Mooney Radio Supply Co.

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*NORFOLK*
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Radio Equipment Co.
Radio Parts Distributing Co.
Radio Supply Co.
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Radio Supply Co.
Winfree Supply Co.
*ROANOKE*
H. C. Baker Sales Co., Inc.
Leonard Electronic Supply Co.

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Harper-Meggee, Inc.
Radio-Electric Supply Co.
Seattle Radio Supply, Inc.
Western Electronic Supply Co.
Herb E. Zobrist Co.
*TACOMA*
C & G Radio Supply Co.
Wible Radio Supply Co.

### WEST VIRGINIA
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*CHARLESTON*
Chemcity Radio & Electric
*HUNTINGTON*
Electronic Supply, Inc.
King & Irwin, Inc.
*PARKERSBURG*
Randle & Hornbrook

### WISCONSIN
*GREEN BAY*
Northern Electrical Dist.
*MADISON*
Radio Distributors
Satterfield Radio Supply
*MANITOWOC*
Harris Radio Corp.
*MILWAUKEE*
Acme Radio Supply Corp.
Central Radio Parts Co.
Electro-Pliance Distrib.
Marsh Radio Supply Co.
Radio Parts Co., Inc.
*RACINE*
Standard Radio Parts Co.
*WAUSAU*
Radio Service & Supply

### WYOMING
*CHEYENNE*
Houge Radio & Supply

## WILCOX ...First Choice for Transatlantic Airline Communication

The whirling propellers of the international air lines make daily mockery of the vast space of the Atlantic Ocean. Intercontinental passengers and cargo come and go hourly at New York, Miami, Gander; Shannon, Ireland, and Lisbon, Portugal. These European and American airports are equipped with modern long-range, multichannel WILCOX Transmitters.

Oslo, Norway, and Stockholm, Sweden, use WILCOX Transmitters as basic communications equipment, and radio beacon service is provided at Reykjavik, Iceland, by WILCOX Type 96-200 Transmitters.

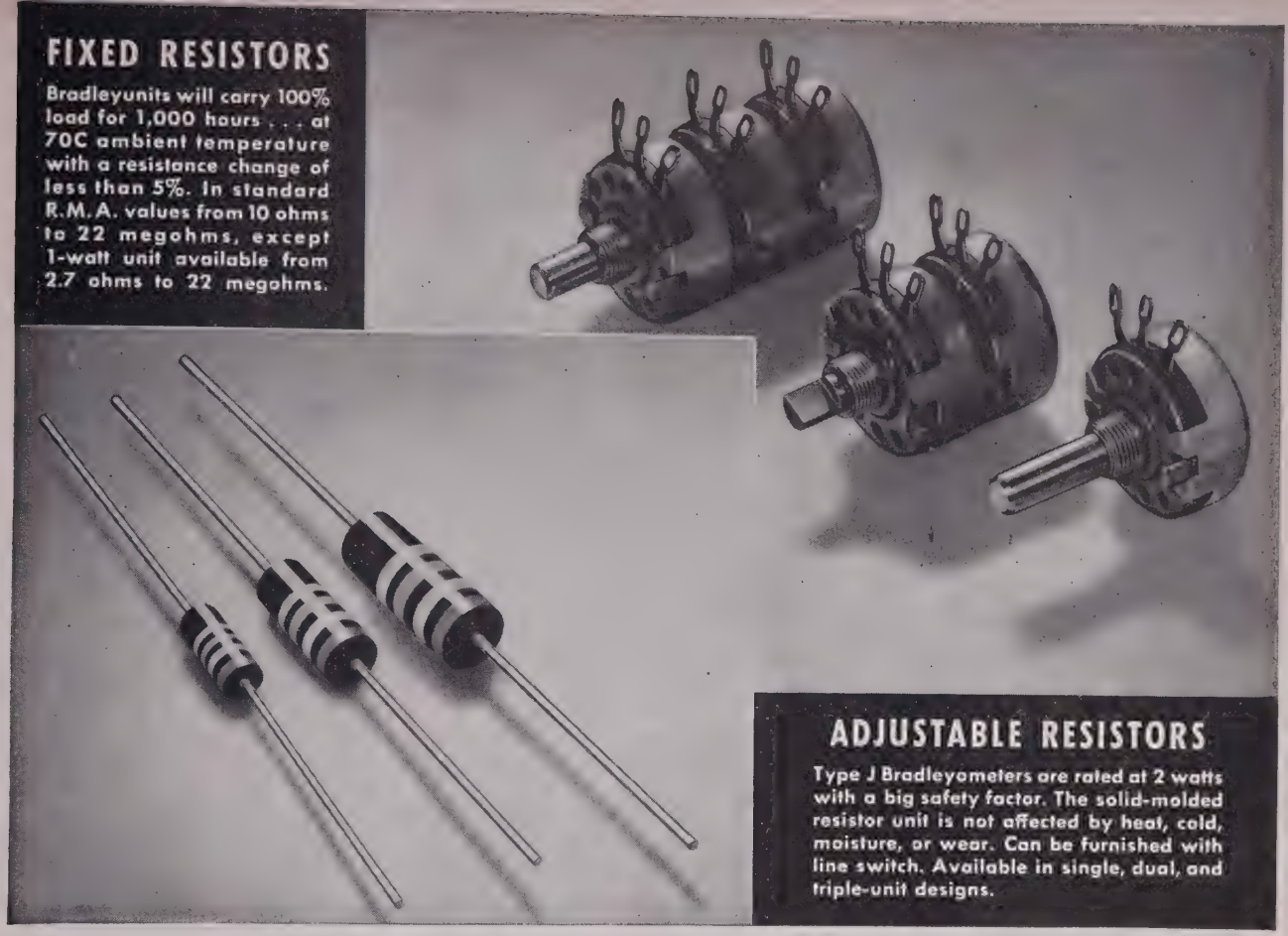
Thus, the giant airliners of the world's major airways are protected in flight and guided safely to the runways of Europe's and America's principal ports of entry.

WRITE TODAY...for complete information on air-borne, ground station, point-to-point, or shore-to-ship communications equipment.

**WILCOX ELECTRIC COMPANY**
KANSAS CITY MISSOURI

## FIXED RESISTORS

Bradleyunits will carry 100% load for 1,000 hours . . . at 70C ambient temperature with a resistance change of less than 5%. In standard R.M.A. values from 10 ohms to 22 megohms, except 1-watt unit available from 2.7 ohms to 22 megohms.



## ADJUSTABLE RESISTORS

Type J Bradleyometers are rated at 2 watts with a big safety factor. The solid-molded resistor unit is not affected by heat, cold, moisture, or wear. Can be furnished with line switch. Available in single, dual, and triple-unit designs.

# For circuits that require resistors of unsurpassed quality ...*Specify* Allen-Bradley

**BRADLEYUNITS** are available in ½, 1, and 2-watt ratings. They have high mechanical strength and permanent electrical characteristics.

The leads are differentially tempered to prevent sharp bends near the resistor. The leads are easily formed to fit any spot.

All Bradleyunits are packed in convenient honeycomb cartons that keep the leads straight. Send for Allen-Bradley resistor chart.

**TYPE J BRADLEYOMETERS** have solid-molded resistor elements. They are thick rings, molded to provide any resistance-rotation curve. After molding, heat, cold, moisture, and hard use do not affect the resistor.

The resistor is molded as a single unit with insulation, terminals, face plate, and treaded bushing in ONE piece. There are no rivets, nor welded or soldered connections.

Allen-Bradley Co., 114 W. Greenfield Ave., Milwaukee 4, Wis.

A·B Quality

# ALLEN-BRADLEY

## FIXED & ADJUSTABLE RADIO RESISTORS

Sold exclusively to manufacturers QUALITY of radio and electronic equipment

# Six More TRUSCON TOWERS OF STRENGTH

## FIVE ARE 400 FT. HIGH

YOU'RE LOOKING AT 2,400 soaring feet of self-supporting radio towers—Truscon-engineered and erected for WFMJ Broadcasting Company in Youngstown, Ohio. These sturdy steel structures climb 400 feet above the Mahoning Valley. One tower carries an RCA 4-section Pylon FM antenna. Together, they give 5,000-watt WFMJ top coverage of the bustling eastern Ohio-western Pennsylvania industrial area.

Competition for Youngstown dialers is intense, with nearby Cleveland and Pittsburgh broadcasters pouring 50,000-watt signals into the market. Facing this problem, Truscon furnished a tower set-up that was exactly right for WFMJ's needs—and then erected the towers for best operating efficiency.

It's one more example of the way in which Truscon engineers tackle *purely local problems* — operational or geographical — in any part of the world. Truscon can engineer and erect exactly the towers you need . . . tall or small . . . guyed or self-supporting . . . for AM, FM or TV. Your phone call or letter to our home office, or to any close-by Truscon District Office, will bring you helpful assistance without obligation.

*WFMJ Broadcasting Station, Poland—Boardman Road, Youngstown, Ohio. 6 Truscon Self-Supporting Towers. One Tower is 346 ft. high with RCA 4-Section Light or Heavy Duty Pylon. Five Towers each 400 ft. high. Shows base of one tower.*

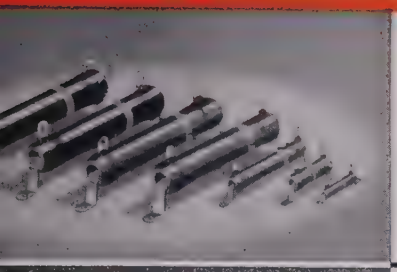
**TRUSCON STEEL COMPANY**
YOUNGSTOWN 1, OHIO
Subsidiary of Republic Steel Corporation

**TRUSCON SELF-SUPPORTING AND UNIFORM CROSS SECTION GUYED TOWERS**

TRUSCON COPPER MESH GROUND SCREEN

# OHMITE Resistors

# Sizes and Types for Every Service

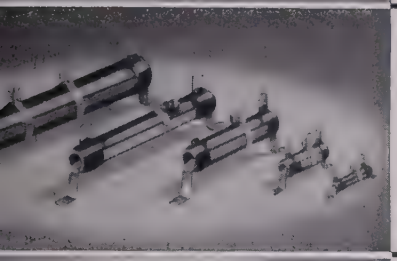


### LUG TYPE

Most popular type for general purpose applications. Connected by soldering or bolting to lugs. Protected by vitreous enamel coating.

### FERRULE TYPE

Winding terminated on metal bands for mounting in standard fuse clips. Provides easy interchangeability without tools.

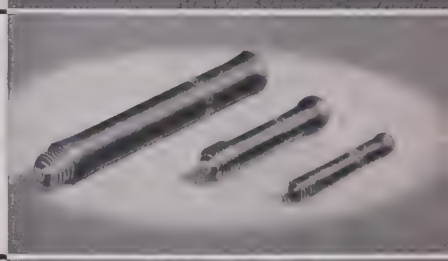


### "DIVIDOHM" ADJUSTABLE TYPE

Provided with adjustable lugs for securing odd values of resistance quickly and easily.

### EDISON BASE TYPE

Mounted in ordinary lamp type screw sockets for easy interchangeability without the use of tools.

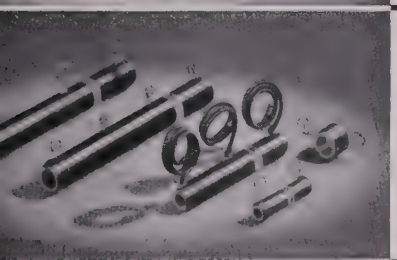


### WIRE LEAD TYPE

Small vitreous enameled resistors which can be connected and supported by their own wire terminals. Maximum size approx. 20 watts.

### PRECISION TYPE

Low wattage resistors of ± 1% or closer tolerance. Made in vacuum impregnated, glass sealed, or vitreous enameled type units.

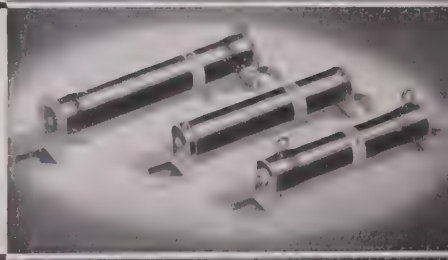


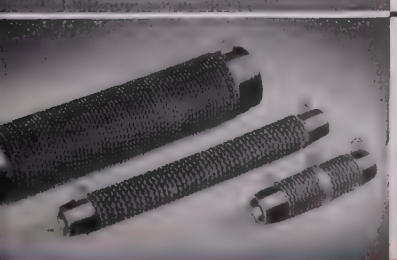
### FLEXIBLE LEAD TYPE

Winding is connected to stranded bare or insulated leads. Used where it is desired to have connecting wires a part of the resistor.

### BRACKET TYPE

Have metal end brackets. Live bracket type is connected by bolting brackets to panel terminals. Dead bracket type has separate lugs.





### "CORRIB" TYPE

Has edge-wound, exposed corrugated ribbon winding. For low resistances where 100 watts or more must be dissipated in small space.

### NONINDUCTIVE TYPE

For radio frequency circuits where constant resistance and impedance are required. Made in rugged, vitreous-enameled type construction.

In addition to the many types of resistors shown above, Ohmite offers resistors in more than sixty different core sizes, and a wide range of wattages and resistance values. Ohmite engineers will be pleased to help you in selecting the right resistors for your needs.


**OHMITE MANUFACTURING CO.**

4862 Flournoy Street Chicago 44, Illinois

*Write on Company Letterhead for Catalog and Engineering Manual No. 40.*

Contains 96 pages of useful data on the selection and application of rheostats, resistors, tap switches, and other equipment.

*Be Right with...*

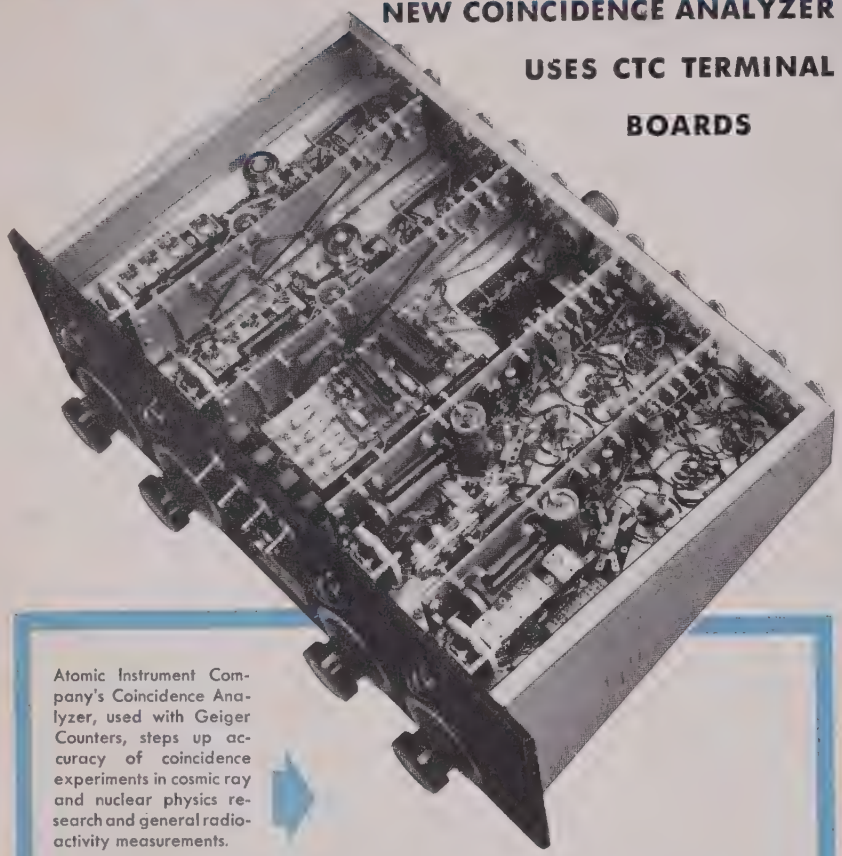
**OHMITE**

RESISTORS · RHEOSTATS · TAP SWITCHES

*Industry's First Choice*

# How CTC worked with an Equipment Manufacturer

## NEW COINCIDENCE ANALYZER USES CTC TERMINAL BOARDS



Atomic Instrument Company's Coincidence Analyzer, used with Geiger Counters, steps up accuracy of coincidence experiments in cosmic ray and nuclear physics research and general radioactivity measurements.

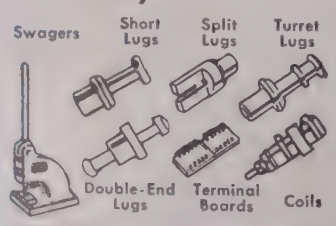
Teamwork between the engineering departments of Atomic Research Company and CTC licked a serious time problem in the manufacture of the Coincidence Analyzer. Atomic Research Company specified what they needed in terminal boards and CTC saw to it that they got what they wanted in a hurry. Five Terminal Boards made of laminated phenolic and equipped with standard CTC feedthrough and single-ended lugs comprise CTC's contribution to this excellent piece of equipment.

This is but one of many cases where CTC has cooperated with electronic and radio manufacturers with gratifying results. We are set up to create and produce assembled terminal boards to meet just about any specifications. Special terminal lugs, coils and chokes to fit particular requirements are also part of our custom engineering service.

### WHAT IS YOUR PROBLEM?

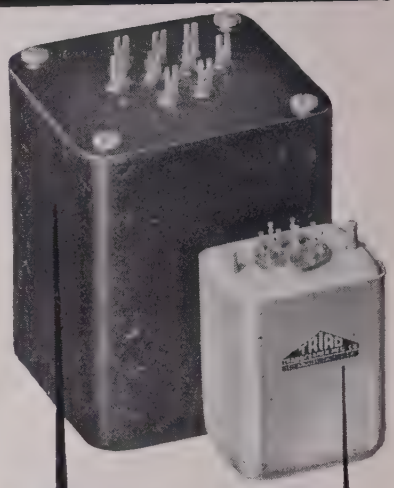
When you need terminal boards, check with us before your designs are too far advanced. Our engineers' long experience with laminated insulating materials offer you expert analysis and satisfactory recommendations, promptly. CTC's broad line of terminals usually fulfills any requirement.

*Custom or Standard*
**The Guaranteed Components**




**CAMBRIDGE THERMIONIC CORP.**
456 Concord Ave., Cambridge 38, Mass.

# Save Space and Weight with TRIAD "HS" Transformers



*1939 Transformer*
*Dims:* $3\frac{3}{8}$" x $3\frac{3}{8}$" x $3\frac{7}{8}$"
*Weight:* $2\frac{3}{4}$ lbs.

*TRIAD "HS" Audio Input Transformer*
*Dims:* $1\frac{7}{16}$" x $1\frac{3}{4}$" x $2\frac{1}{2}$"
*Weight:* 12 oz.

Both transformers shown above are high fidelity input transformers, frequency response from 20-20,000 cycles and 95db. shielding.

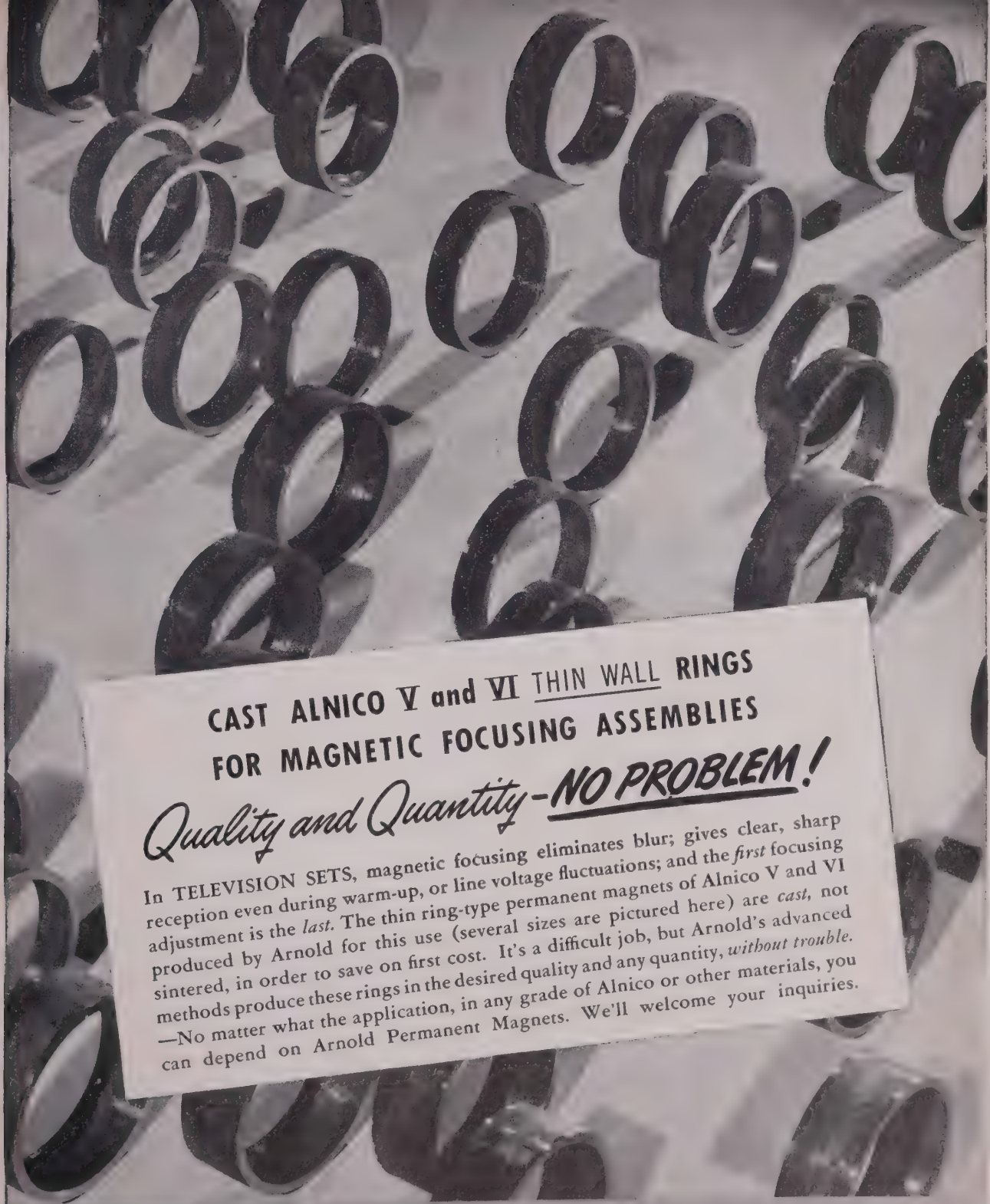
Yet the Triad transformer is only **one-seventh as large by volume,** occupies **one-fourth the space** and is **one-fourth as heavy.** In the production of today's high fidelity equipment, where space is at a premium, that's important.

Triad "HS" (hermetically sealed) transformers, built to meet JAN specifications, are providing new standards of performance for quality electronic equipment—yet they cost little more than ordinary cased types.

Triad builds a complete line of transformers for original equipment, replacement, geophysical and amateur applications.

Write for Catalog TR-49

**TRIAD**
**TRANSFORMER MFG. CO.**
**2254 Sepulveda Blvd.**
**Los Angeles 64, Calif.**



**CAST ALNICO V and VI THIN WALL RINGS FOR MAGNETIC FOCUSING ASSEMBLIES**

*Quality and Quantity* — **NO PROBLEM!**

In TELEVISION SETS, magnetic focusing eliminates blur; gives clear, sharp reception even during warm-up, or line voltage fluctuations; and the *first* focusing adjustment is the *last*. The thin ring-type permanent magnets of Alnico V and VI produced by Arnold for this use (several sizes are pictured here) are *cast*, not sintered, in order to save on first cost. It's a difficult job, but Arnold's advanced methods produce these rings in the desired quality and any quantity, *without trouble*. —No matter what the application, in any grade of Alnico or other materials, you can depend on Arnold Permanent Magnets. We'll welcome your inquiries.

**THE ARNOLD ENGINEERING COMPANY**

Subsidiary of

ALLEGHENY LUDLUM STEEL CORPORATION

147 East Ontario Street, Chicago 11, Illinois

***Specialists and Leaders in the Design, Engineering and Manufacture of PERMANENT MAGNETS***

## . . . the economy of thoriated-tungsten filaments and improved cooling in high-power tubes

*Here is unparalleled tube value . . .*

Five new RCA tubes, ranging in power input from 1.5- to 150-kw, and successfully utilizing economical thoriated-tungsten filaments which offer marked savings in filament power and the cost of associated power equipment.

Five tubes with proved features of previous similar types. Two—the 5762 and 5786—have efficient newly designed radiators that permit the use of less expensive blowers.

Five tubes with improved internal constructions that contribute to their more efficient operation and longer service life.

These five new RCA tube types are "musts" for designers of broadcast, communications and industrial electronic equipment where design and operating economies alike are important considerations.

Forced-air-cooled assemblies and water-jacket assemblies are available for most RCA power tubes.

**RCA Application Engineers** are ready to consult with you on the application of these improved tubes and accessories to your specific designs. For complete technical information covering the types in which you are interested, write RCA, Commercial Engineering, Section 47LR, Harrison, New Jersey.

RCA

TUBE DEPARTMENT

RADIO CORPORATION of AMERICA

HARRISON, N. J.

# ADVENTURES IN ELECTRONIC DESIGN

## 'Twas The Night Before Christmas

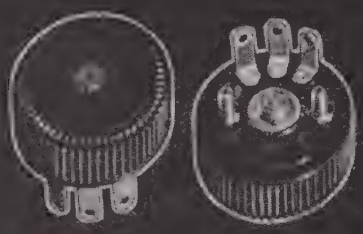
Christmas, 1949 will find more breathless youngsters thrilling to the timeless story of Santa Claus than ever before. It will also find more grown-ups enjoying the beautiful carols and dramatic programs that are so much a part of the Yuletide Season There's no doubt about it Christmas, 1949, will be the merriest ever for millions of people everywhere . . . And a good share of the credit belongs to you . . . America's great radio and television industry Yes, by producing more and finer radio and television receivers than ever before and making these sets available at prices practically every family can afford, you are playing a vital role in making the world a better place in which to live. For this great accomplishment Centralab supplier of quality parts to the radio and television industry for more than 25 years salutes you and wishes you a very merry Christmas!

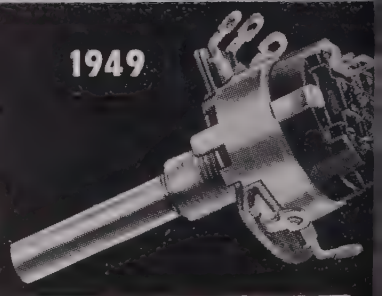
**Centralab** CRL ® – DEVELOPMENTS THAT HAVE HELPED YOU SINCE 1922!

# Centralab reports to

**DECEMBER, 1949**
**How Centralab's "Famous Firsts" have helped You since 1922!**

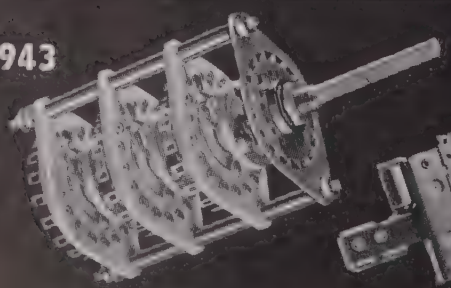
## CONTROLS






Centralab has come to be known in the electronics industry as "first" in the majority of the products it manufactures and sells. Originator of the Composition Type Volume Control, in 1922. The first Barnacle Type Line Switch attached to a volume control, in 1929. Model 1, smallest switch type hearing aid control, 1946. Now, 1949, Model 2 Radiohm, the most modern high quality variable resistor.

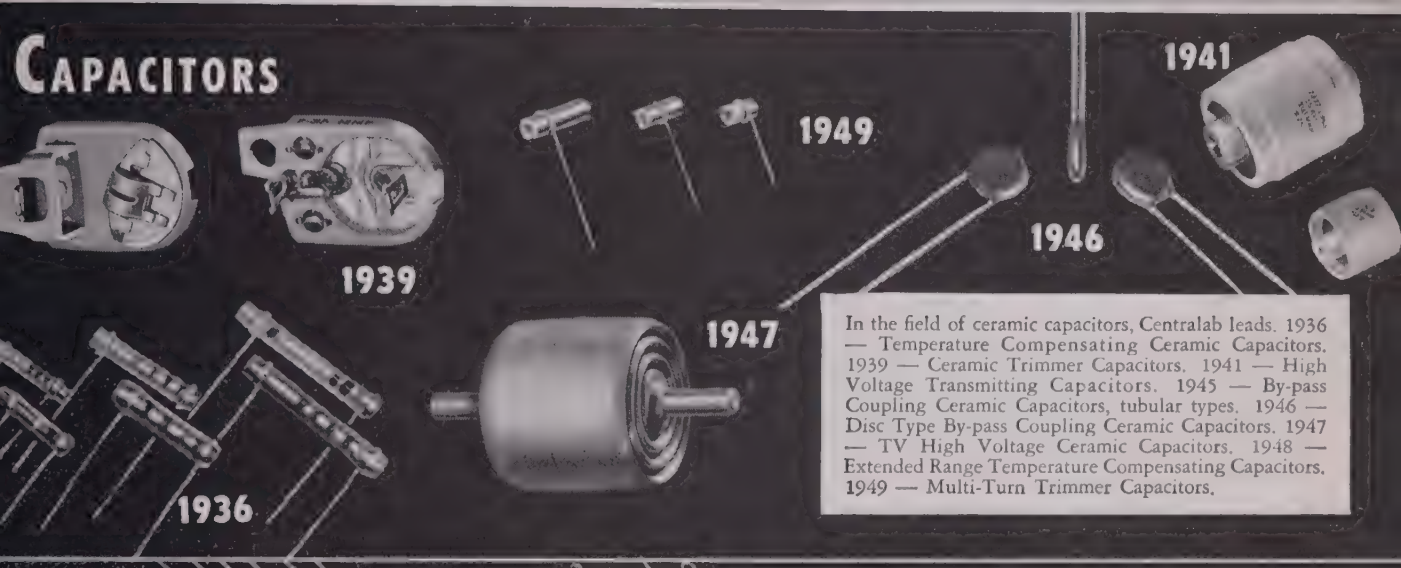
## SWITCHES



In 1936, Centralab introduced a complete line of wave band and tone switches. First in switch development. A 24 contact per single section switch in 1938. Lever Action Switch in 1939. Low-loss, high-frequency, medium-duty Power Switch, 1943. FM and TV Slide Switch, 1947.

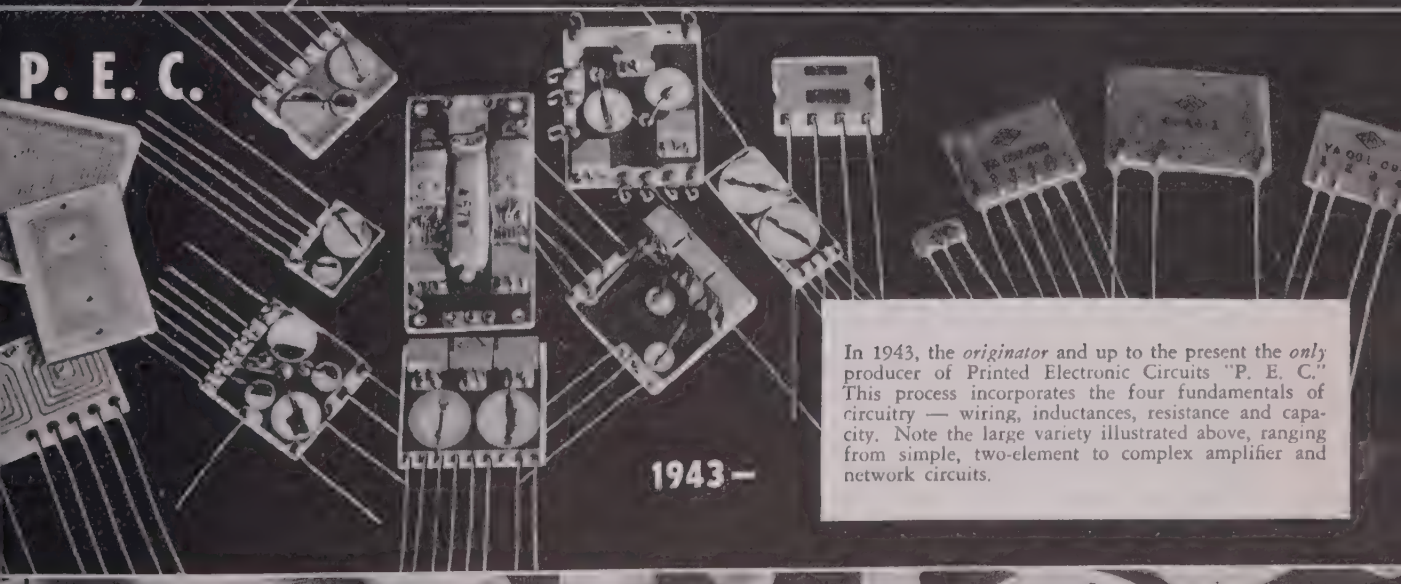
# Electronic Industry

## CAPACITORS




In the field of ceramic capacitors, Centralab leads. 1936 — Temperature Compensating Ceramic Capacitors. 1939 — Ceramic Trimmer Capacitors. 1941 — High Voltage Transmitting Capacitors. 1945 — By-pass Coupling Ceramic Capacitors, tubular types. 1946 — Disc Type By-pass Coupling Ceramic Capacitors. 1947 — TV High Voltage Ceramic Capacitors. 1948 — Extended Range Temperature Compensating Capacitors. 1949 — Multi-Turn Trimmer Capacitors.

## P. E. C.

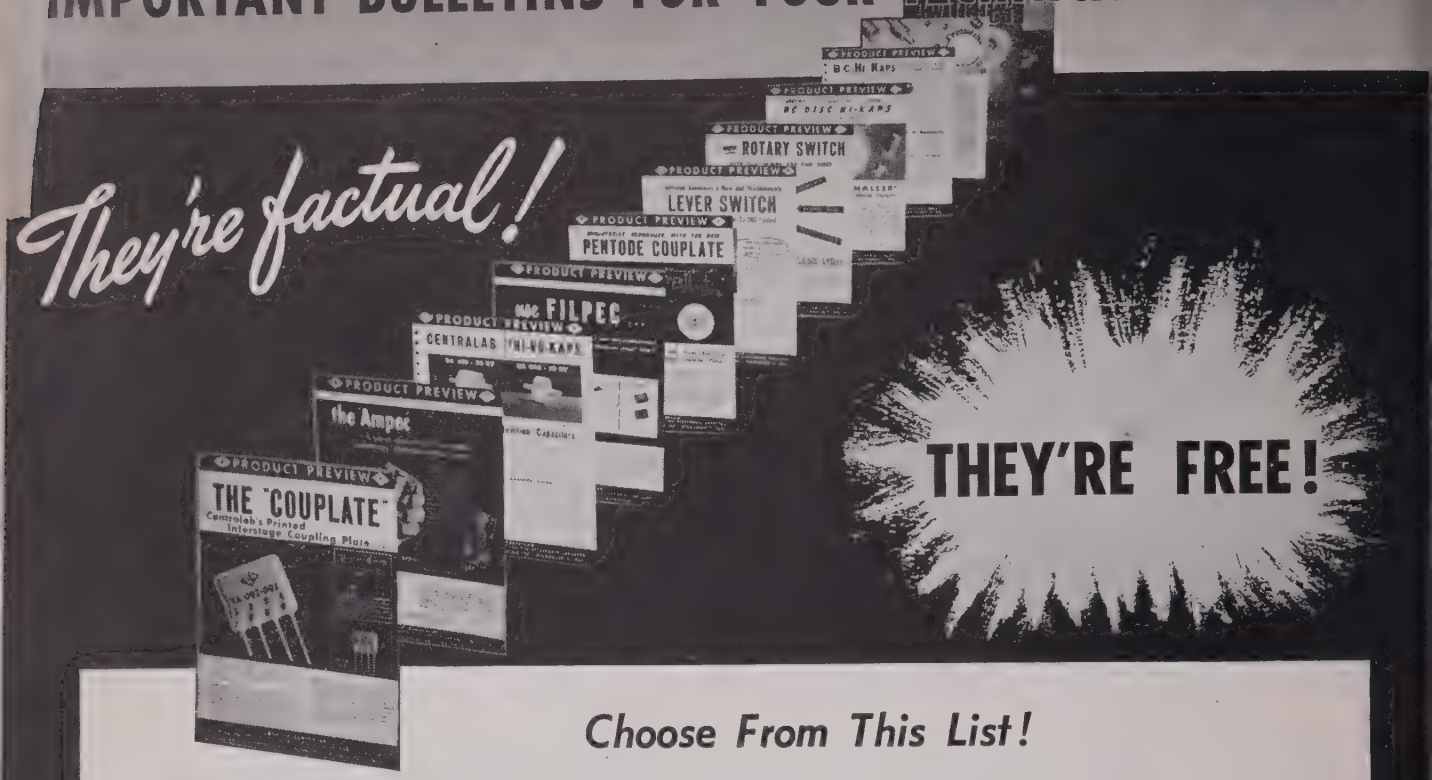



In 1943, the *originator* and up to the present the *only* producer of Printed Electronic Circuits "P. E. C." This process incorporates the four fundamentals of circuitry — wiring, inductances, resistance and capacity. Note the large variety illustrated above, ranging from simple, two-element to complex amplifier and network circuits.

## CERAMICS

In 1942 Centralab developed a grade L-5 Steatite Ceramic superior to the then existing navy grade "G" specification. In 1944 a grade L-6 was introduced. In 1945, Cordierite and Zircomite bodies with grade L-4 rating were developed. Since 1943, Centralab has led in the metalizing of ceramic bodies for special purposes.

# IMPORTANT BULLETINS FOR YOUR TECHNICAL LIBRARY!




## Choose From This List!

### Centralab Printed Electronic Circuits

**973** — AMPEC — three-tube P. E. C. amplifier.
**42-6** — COUPLATE — P. E. C. interstage coupling plate.
**999** — PENTODE COUPLATE — specialized P. E. C. coupling plate.
**42-9** — FILPEC — Printed Electronic Circuit filter.

### Centralab Capacitors

**42-3** — BC TUBULAR HI-KAPS — capacitors for use where temperature compensation is unimportant.
**42-4** — BC DISC HI-KAPS — miniature ceramic BC capacitors.
**42-10** — HI-VO-KAPS — high voltage capacitors for TV application.
**695** — CERAMIC TRIMMERS — CRL trimmer catalog.
**981** — HI-VO-KAPS — capacitors for TV application. For jobbers.
**42-18** — TC CAPACITORS — temperature compensating capacitors.
**814** — CAPACITORS — high-voltage capacitors.
**975** — FT HI-KAPS — feed-thru capacitors.

### Centralab Switches

**953** — SLIDE SWITCH — applies to AM and FM switching circuits.
**970** — LEVER SWITCH — shows indexing combinations.
**995** — ROTARY SWITCH — schematic application diagrams.
**722** — SWITCH CATALOG — facts on CRL's complete line of switches.

### Centralab Controls

**42-7** — MODEL "1" RADIOHM — world's smallest commercially produced control.
**697** — VARIABLE RESISTORS — full facts on CRL Variable Resistors.

### Centralab Ceramics

**967** — CERAMIC CAPACITOR DIELECTRIC MATERIALS.
**720** — CERAMIC CATALOG — CRL steatite, ceramic products.

### General

**26** — GENERAL CATALOG — Combines Centralab's line of products for jobber, ham, experimenter, serviceman or industrial user.

***Look to CENTRALAB in 1950!*** First in component research that means lower costs for the electronic industry. If you're planning new equipment, let Centralab's sales and engineering service work with you. For complete information on all CRL products, get in touch with your Centralab Representative. Or write direct.

CENTRALAB
Division of Globe-Union Inc.
900 East Keefe Avenue, Milwaukee, Wisconsin

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**for the Bulletins you want**

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## POSITIONS OPEN

*(Continued from page 50A)*

Agency, Washington 25, D.C. in the field of electronics for electrical engineers, grades P-3, $3727.50 per annum through P-5, $6235.20 per annum. Minimum requirements are a Masters degree or a Bachelors degree from an accredited college or university, plus 1 year of professional engineering experience. All positions are permanent in so far as the Agency is concerned. Address reply to: Chief, Army Security Agency, CS GAS-61, The Pentagon, Washington 25, D.C.

### RADAR ENGINEER—PHYSICIST

Must have heavy experience in basic study and research on new radar systems and similar electronic equipment. Excellent opportunity for senior man. Juniors please do not apply. State particulars, reply confidential, to A. Hoffsommer, The W. L. Maxson Corp., 460 West 34 Street, New York 1, N.Y.

### PATENT ENGINEER

A manufacturer of electrical and mechanical devices in the New York City area, is in need of a man with legal, patent and engineering training and some experience, to act as liaison between engineers and sales executives and outside patent counsel. In reply give full particulars of experience and training. Address reply to Box 582.

*(Continued on page 52A)*


## PROJECT ENGINEERS

Real opportunities exist for Graduate Engineers with design and development experience in any of the following: Servomechanisms, radar, microwave techniques, microwave antenna design, communications equipment, electron optics, pulse transformers, fractional h.p. motors.

SEND COMPLETE RESUME TO EMPLOYMENT OFFICE.

**SPERRY**
**GYROSCOPE CO.**
DIVISION OF
THE SPERRY CORP.
GREAT NECK, LONG ISLAND



## An EASY and ACCURATE Way to Measure Audio Frequency Voltages

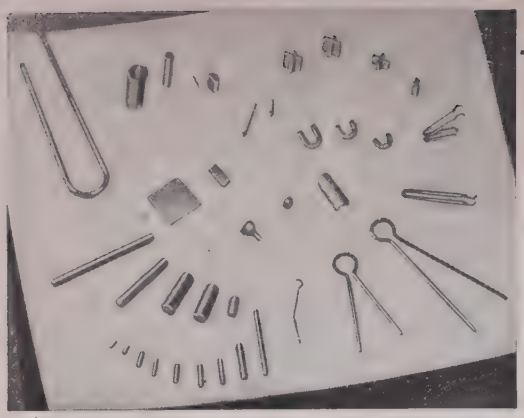
**Ballantine Model 300**
**SENSITIVE ELECTRONIC VOLTMETER**
**Featuring a Logarithmic Voltage Scale and Uniform Decibel Scale**

● Designed for the measurement of AC Voltages from .001 Volt to 100 Volts over a frequency range of 10 to 150,000 cycles. ● Accuracy of readings is ±2% at any point on the scale. ● Very stable calibration -unaffected by changes in line voltage, tubes or circuit constants. ● Range switching in decade steps—easy to use—only ONE scale to read. ● Output jack and output control provided so that Voltmeter can be used as a high-gain (70 DB) high-fidelity amplifier. ● Accessories available to extend readings up to 10,000 Volts and down to 10 microvolts. ● Precision Shunt Resistors convert Model 300 Voltmeter to very sensitive direct-reading milliammeter. ● Write for complete data.

**PRICE . . . . . $200.00**

**BALLANTINE LABORATORIES, INC.**
**BOONTON N. J. • U.S.A.**

**In addition to the Model 300 Voltmeter, Ballantine Laboratories also manufacture Battery Operated Electronic Voltmeters, R. F. Electronic Voltmeters, Peak to Peak Electronic Voltmeters, and the following accessories—Decade Amplifiers, Multipliers, Precision Shunt Resistors, etc.**



# NEY
## PRECIOUS METALS
FOR
**ELECTRICAL CONTACTS ON POTENTIOMETERS, SLIP RINGS, RELAYS AND SWITCHES**

### PALINEY #7
SLIDING CONTACTS FOR POTENTIOMETERS

PALINEY #7 is being used for a contact material on potentiometers wound with a nickel-chrome alloy resistance wire. This combination is consistently producing units with life of better than one million cycles and maintained accuracy of 0.1% or better throughout the life of the unit.

### NEY-ORO #28
SLIP RING BRUSHES

NEY-ORO #28 is a special alloy developed as a contact brush material for uses against coin silver slip rings. Laboratory tests and reports from users indicate life of better than 10 million revolutions with no electrical noise.

*Write or telephone* (HARTFORD 2-4271) *our Research Department*

**THE J. M. NEY COMPANY** 171 ELM STREET • HARTFORD 1, CONN.

SPECIALISTS IN PRECIOUS METAL METALLURGY SINCE 1812

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# V. L. F.!
*Very Low Frequencies covered by the . . .*

## STODDART NM-10A RADIO INTERFERENCE AND FIELD INTENSITY METER

- MEASURES radiated and conducted signals, including pulse or random interference.
- RANGE—14 kc to 250 kc.
- SENSITIVITY [illegible] rod antennas [illegible] to 2 volts-per-meter. Field strength using shielded [illegible] microvolts-per-meter to 100 volts-per-meter. As a two-terminal voltmeter, either balanced or unbalanced, one microvolt to one volt.
- READS directly in microvolts and db.
- A.C. POWER SUPPLY REQUIREMENTS 105 to 125 volts or 210 to 250 volts A.C. Single phase source may be ANY FREQUENCY BETWEEN 50 CPS AND 1600 CPS. No shock hazard.
- GRAPHIC RECORDER included with versatile complement of accessories.

Write for complete technical data

**STODDART AIRCRAFT RADIO CO.**

Main office and plant: 6644 Santa Monica Blvd. Hollywood 38, Calif. Phone: Hillside 9294

8-247 General Motors Bldg. Detroit 2, Michigan Phone: Trinity 1-2260

1346 Connecticut Ave. duPont Circle Bldg. Washington 6, D. C. Phone: Hudson 7313


## POSITIONS OPEN

*(Continued from page 51A)*

### ELECTRONIC ENGINEER

College graduate, E.E., with 3 or more years experience in electronic circuit design. Expanding consulting firm, specialists in custom building of industrial electronic instruments, has opening for fast-thinking engineer who can apply theoretical background to practical problems. Location Detroit, Michigan. Box 584.

### ELECTRICAL ENGINEERS

Graduates in electrical engineering or physics with at least 3 years design and manufacturing experience on radio transmitters or radar equipment. Non-graduates having at least 6 years similar practical experience will be considered also. Address reply to Personnel Manager, RCA Victor Company, Ltd., Montreal, Canada.

### SALES ENGINEER

Sales Department of small company engaged in research, development and manufacture of instruments specializing in the radiation field, requires an engineer with sales promotion experience demonstrating qualities of aggressive leadership, ability in business, business correspondence and a good knowledge of electronics. Must be capable of planning sales functions and following them through to a successful conclusion. Con-

*(Continued on page 53A)*


# ENGINEERING OPENINGS
at
# DuMONT TELEVISION

- **ELECTRONIC PROJECT ENGINEER**
  Development & design of UHF tuning devices. Must have related experience.
- **ELECTRONIC ENGINEER**
  Television receiver circuit design & development; preferably experienced in synchronizing problems.
- **MECHANICAL PROJECT ENGINEER**
  Development & design of UHF tuning devices. Must be familiar with die casting & injection molding technique.
- **MECHANICAL ENGINEER**
  Experienced in product design of home radios or television receivers.

Call in person or write:

**Allen B. DuMont Laboratories**
Personnel Dept., Television Receiver Division
East Patterson, N.J.

Interviews outside of N.Y. area may be arranged.

## Positions Open

*(Continued from page 52A)*

tact, Berkeley Scientific Co., 6th & Nevin, Richmond, California.

TELEVISION ANTENNA ENGINEER

Well established New York City manufacturer has an immediate opening for engineer with thorough up-to-the-minute knowledge of commercial television receiving antenna theory, design and construction. Duties include sales engineering and execution of graphs and test patterns. Write Box 583.

VACUUM TUBE ENGINEER

4-5 years experience microwave measurements, circuits or electronics. Some tube engineering and construction experience helpful. Ability to direct development projects. B.S. in E.E. or physics minimum. Large company No. New Jersey. Write in detail Personnel Dept. Box 586.

★ ★ ★ ★

## Positions Wanted By Armed Forces Veterans

In order to give a reasonably equal opportunity to all applicants, and to avoid overcrowding of the corresponding column, the following rules have been adopted:

*(Continued on page 54A)*


## RCA VICTOR
## Camden, N. J.

***Requires Experienced Electronics Engineers***

RCA's steady growth in the field of electronics results in attractive opportunities for electrical and mechanical engineers and physicists. Experienced engineers are finding the "right position" in the wide scope of RCA's activities. Equipment is being developed for the following applications: communications and navigational equipment for the aviation industry, mobile transmitters, microwave relay links, radar systems and components, and ultra high frequency test equipment.

These requirements represent permanent expansion in RCA Victor's Engineering Division at Camden, which will provide excellent opportunities for men of high caliber with appropriate training and experience.

If you meet these specifications, and if you are looking for a career which will open wide the door to the complete expression of your talents in the fields of electronics, write, giving full details to:

National Recruiting Division
Box 147, RCA Victor Division
Radio Corporation of America
Camden, New Jersey

# THIS IS THE HORNET

## A NEW MINIATURE POWER TRANSFORMER FOR USE IN AIRBORNE & PORTABLE EQUIPMENT

*Illustration shows relative size of HORNET and conventional transformers of comparable capacity.*

***FEATURING***

**SMALLER SIZE**

than any previous design, through the use of newly developed class H insulating materials, and design techniques. As shown above, HORNET transformers are only about one-fourth the size of similarly rated conventional transformers.

**GREATER POWER OUTPUT**

because of improved design and construction. HORNET transformers operate with unimpaired efficiency at high temperatures, and are suitable for operation at ambient temperatures as high as 150 deg. C. High output plus smaller size and lighter weight make these units ideal for use in airborne and portable equipment.

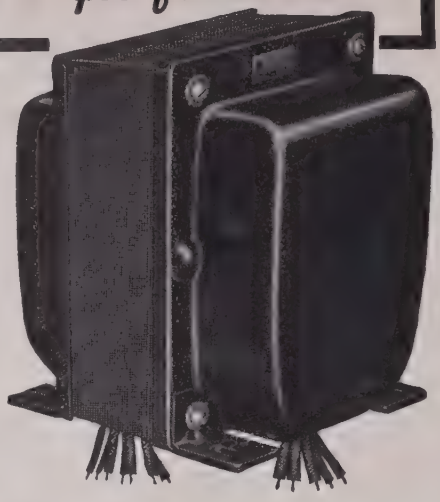
**MEETS JAN SPECIFICATIONS**

HORNET transformers are designed and built to meet requirements of current JAN T-27, and equivalent specifications.

***Write for descriptive bulletin of sizes and specifications***

**NEW YORK TRANSFORMER CO., INC.**
ALPHA, NEW JERSEY

# NEW T. V. IDEAS
## NEED ACME ELECTRIC TRANSFORMER *performance*

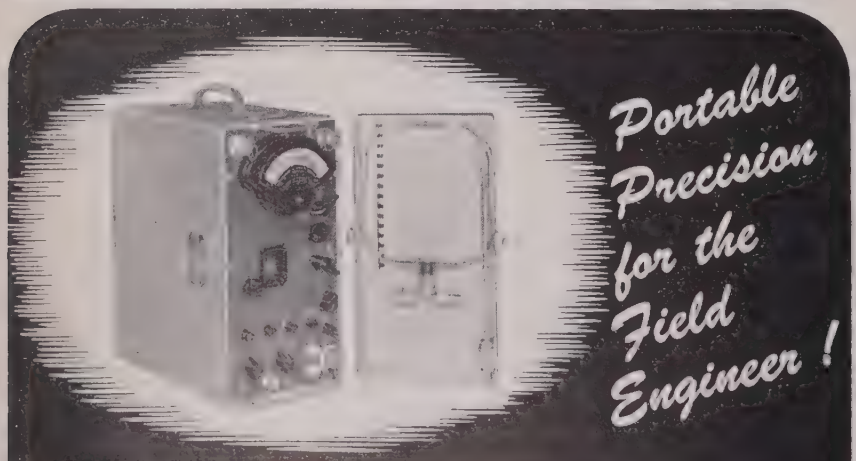


New engineering ideas, to advance the reception qualities of Television, need better than average transformer performance. Acme Electric engineers will assist your ideas by helping you design a transformer, exactly in accordance with your needs.

Acme ACME Electric
TRANSFORMERS

ACME ELECTRIC
Corporation
4412 Water St. Cuba, N.Y., U.S.A.





*Portable Precision for the Field Engineer!*

## STODDART NM-20A
## RADIO INTERFERENCE AND FIELD INTENSITY METER

- A portable unit that you can DEPEND upon! Designed especially to withstand the rigors of all-weather field operation and yet provide reliable performance.
- Measures FIELD INTENSITIES of radio signals and r.f. disturbances with either a rod antenna or a rotatable loop antenna.
- May be used as a two-terminal r.f. voltmeter (balanced or unbalanced), frequency selective over the CONTINUOUS RANGE 150 kc to 25 mc.
- ONE MICROVOLT SENSITIVITY as a two-terminal voltmeter; 2 microvolts-per-meter using rod antenna.
- Operates from self-contained dry batteries or external A.C. power unit providing well-regulated filament and plate supplies.

Write for complete [illegible] data

STODDART AIRCRAFT RADIO CO.

Main office and plant:
6644 Santa Monica Blvd.
Hollywood 38, Calif.
Phone: Hillside 9294

8-247 General Motors Bldg.
Detroit 2, Michigan
Phone: Trinity 1-9260

1346 Connecticut Ave.
DuPont Circle Bldg.
Washington 6, D. C.
Phone: Hudson 7313


# Positions Wanted

*(Continued from page 53A)*

The Institute publishes free of charge notices of positions wanted by I.R.E. members who are now in the Service or have received an honorable discharge. Such notices should not have more than five lines. They may be inserted only after a lapse of one month or more following a previous insertion and the maximum number of insertions is three per year. The Institute necessarily reserves the right to decline any announcement without assignment of reason.

### DEVELOPMENT ENGINEER

Eight years broad experience, research and development. Servos, auto, controls, analogue computers, industrial electronics. Excellent theoretical ability well balanced by laboratory and experimental work. High scholastic standing in college. Desires position as Senior Development Engineer or Assistant Director of Research. Box 321 W.

### ENGINEER

B.E.E. Cum Laude, C.C.N.Y. February 1948. Tau Beta Pi and Eta Kappa Nu. Age 24. 1½ years design, development and production experience as project engineer. Main field antennas. Desires position in New York Metropolitan area. Box 322 W.

### ENGINEER

B.E.E. 1943 C.C.N.Y., M.S. 1948 Columbia University. Age 28. Married. 6 years experience in electronic research and product engineering. 1st class radio telephone license. New York area. Box 323 W.

*(Continued on page 55A)*


## NATIONAL UNION RESEARCH DIVISION

There are several desirable openings for experienced

**PHYSICISTS and ENGINEERS**

capable of handling the design and development of electron tubes and UHF circuits.

Our growing organization can offer excellent prospects for security and advancement to qualified personnel.

Interested applicants are invited to send their résumé to:

Divisional Personnel Manager
National Union Research Division
350 Scotland Road, Orange, N.J.

# Positions Wanted

*(Continued from page 54A)*

### JUNIOR ENGINEER OR LABORATORY TECHNICIAN

Graduate of R.C.A. Institute Technology course. 4 years commercial experience in electronic laboratory technique. Worked for Alexander Fowler and Allen B. Dumont laboratories. Former Air Corps instrument instructor and specialist. Hold 1st class F.C.C. radio and telephone license. Experienced in all phases of laboratory work on video or electronic circuitry. Age 27. Married. Desires New York City area or Long Island. Box 325 W.

### ENGINEER

B.E.E. University of Florida, September 1949. Communications major. 5 years Army service. Age 27. Married, no children. Willing to travel. Box 326 W.

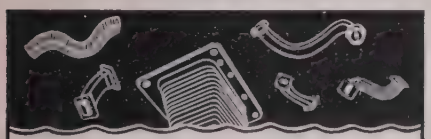
### RADIO ENGINEER

B.S.E.E. University of California, September 1949. Communications major. Age 23. 2 years Navy ETM. Desires position in radio, television, or technical writing. Prefer West coast. Box 327 W.

### MICROWAVE ENGINEER

B.E.E. 1943, graduate evening student. Married. Age 27. 3½ years research and development experience on microwave transmission components and systems. 2 years Army P.P.M. radar link work. Desires research or development work vicinity New York City. Box 328 W.

*(Continued on page 56A)*

FLEXAGUIDE

A flexible waveguide with an electrically continuous FLEXIBLE CONVOLUTED bellows innercore protected by a specially LOW TEMPERATURE flexible molded jacket. It is PRESSURE tight and electrically correct for all conditions of bending and flexing. Standing Wave Ratio is equivalent to standard rigid waveguide assembly throughout the flexing cycle and has excellent attenuation characteristics.

*Send for latest information*

Airtron

DESIGNS and PRODUCES

*Electronic and Aircraft Components*

105 East Elizabeth Avenue

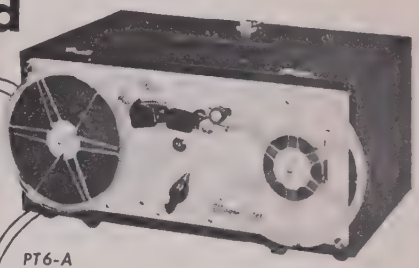
Linden New Jersey

FOR GREATEST *Flexibility* IN PROFESSIONAL TAPE RECORDING

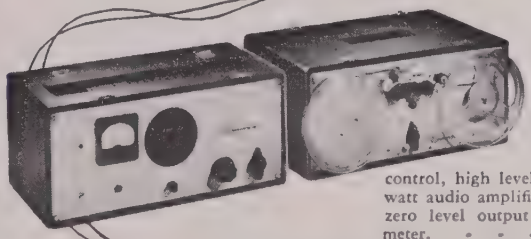
Get Magnecord UNIT CONSTRUCTION

FM STUDIO QUALITY *PLUS* PORTABILITY AND ECONOMY

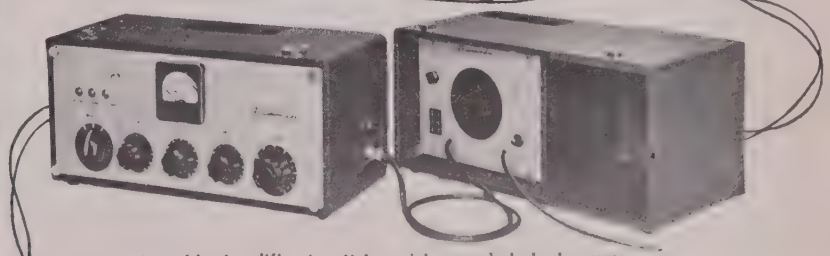
Only Magnecord gives you the economy and adaptability of unit construction plus really high fidelity. The several Magnecord units combine to meet every studio and remote recording demand. Buy only those you need. Carry and use them only where and when you need them.



*PT6-A Recorder Mechanism* is the heart of Magnecord combinations for studio and remote recording. Weighs 26 lbs. in carrying case, easily removable for rack mount. Quick-change capstans for recording at 7½ or 15 inches/sec. High speed rewind. Frequency response 40 to 15,000 cps ± 2 db. - - - - - - - $278



*PT6-JA Recorder & Amplifier* provides complete portable facilities for professional quality reproduction at a new low price. Includes PT6-A Recorder plus amplifier containing low impedance mike input with gain control, high level input, monitor speaker and 10 watt audio amplifier with jack for external speaker, zero level output terminal, VU type meter. - - - - - - - - - $499.50



*PT6-P Portable Amplifier* is a light weight record-playback-remote amplifier plus power supply designed for use with PT6-A Recorder. 3 low level independently mixed mike inputs plus bridging input for use with a line level input. Monitor amplifier and small speaker in power supply section. $462

*PT6-R Rack-Mount Amplifier* is a high fidelity, single channel amplifier for use with existing audio amplifiers and PT6-A Recorder. Uses only 14 inches of rack space. Recorder can be removed from carrying case and fastened to flush mounting in seconds. (Recorder not included). $383

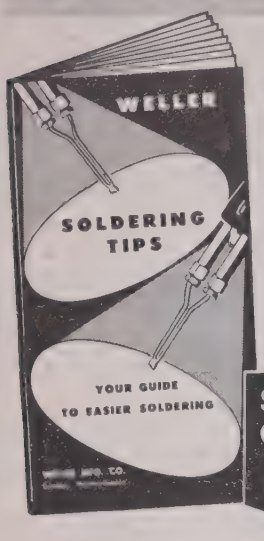
*Write for complete specifications and name of nearest dealer.*

Magnecord, INC., CHICAGO 1, ILL.

360 NORTH MICHIGAN AVENUE

*World's Largest and Oldest Manufacturers of Professional Magnetic Recorders.*

# SOLDERING IS A CINCH



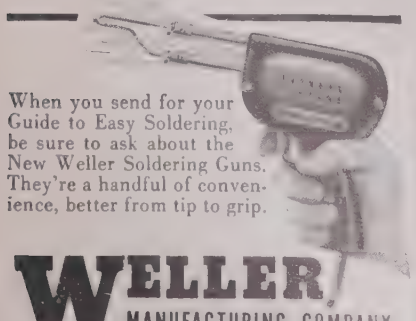

when you know these SIMPLE TRICKS!

SEND NOW ONLY 10¢

No matter how much you know about soldering, there's always a trick that will make it easier. This little 20-page pocket guide is crammed full of such time-and-trouble savers.

Without wasting words, it covers the whole soldering operation—points out DO's and DON'T's—refreshes your memory on difficult points—suggests methods that help you work faster. Yet there's no hard studying, no tough technical talk. Every word is plain everyday English and every point is made clear by easy-to-understand illustrations.

Get this handy Soldering Guide today, and keep it on your bench for ready reference. It's a real handbook of professional soldering—*not* a catalog. Just mail the coupon with 10c in coin and we'll send your copy at once.



When you send for your Guide to Easy Soldering, be sure to ask about the New Weller Soldering Guns. They're a handful of convenience, better from tip to grip.

**WELLER**
MANUFACTURING COMPANY

Weller Mfg. Co., 821 Packer St., Easton, Pa.

Enclosed find ten cents (10c) for which please send my copy of the Weller "Soldering Tips".

☐ *I am also interested in the new Weller Soldering Guns. Please send Catalog Bulletin.*

*Name*_____

*Address*_____

*City*_____ *State*_____


# Positions Wanted

*(Continued from page 55A)*

### ENGINEER

B.S. in Radio Engineering. 3 years Airborne radio and radar maintenance with U.S.M.C. 19 months audio repair with Sound Scriber Distributor. Age 27. Married, 1 child. Desires work in U.H.F. field. Box 329 W.

### ELECTRICAL ENGINEER

B.S.E.E. 1949. Single. Age 23. University of Illinois graduate, upper quarter. Knowledge of Greek. Desires position in Engineering Department of American firm in Europe, preferably Greece. Available immediately. Box 330 W.

### JUNIOR ENGINEER

B.S.E.E. Columbia University, June 1949. Age 28. Single. Desires promising starting position in design development or production, anywhere in United States. Box 331 W.

### COMMUNICATIONS ENGINEER

B.S.E.E. 1947. 2 years carrier telephony, Signal Corps radio-link. Age 27. Married, 2 children. Now employed in Boston, wants research, design, station construction, sales engineering, teaching or technical writing in central to southern Maine. 2 years design of high-frequency and microwave antennas. Box 332 W.

### ELECTRONIC TECHNICIAN

High school graduate. 2 years U. S. Coast Guard radio and radar school. 2 years at RCA Institutes. 5 years experience in radio and radar maintenance and installation with U. S. Coast Guard. 3 years with American Airlines as radar technician in transmitter band experimental radar laboratory. Box 334 W.

### JUNIOR ELECTRICAL ENGINEER

B.S.E.E. June 1949, Bucknell University. Married. 26 months experience as Navy electronic technician. No other experience, but willing to learn. Desires position in electronics in New York City area. Box 352 W.

### COMMUNICATIONS ENGINEER

Graduate of Ohio State University, December 1947 with B.E.E. Married. Age 23. Experience: 1½ years with automatic switching equipment, 1 year part-time in electronics development. Desires position in electronic or communications field in Northern New Jersey area. Box 353 W.

### ELECTRONIC ENGINEER

B.S.E.E. June 1949, State College of Washington. Single. Age 29. 2 years radio operation experience in Army. Desires position in electronic field. Prefer Pacific coast area. Box 355 W.

### ENGINEER

M.S. in physics, June 1949, Fordham University. 2 years experience as part time instructor in general physics lab. Graduate of Navy electronic training program. Age 24. Engaged. Desires position in sales or development, preferably in New York area. Box 356 W.

### ENGINEER

B.S.E.E. June 1949, University of Missouri. Tau Beta Pi, Eta Kappa Nu, Pi Mu [illegible]. Single. Some radio experience in Signal Corps. Desires communications or electronic work. Anywhere in U.S. Box 357 W.

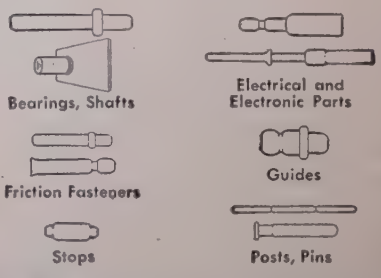
*(Continued)*

# Choose right and make Big Savings on SMALL METAL PARTS

**COSTS HALVED!** Instead of turning and drilling parts like these from solid rod, or stamping and forming them, the BEAD CHAIN MULTI-SWAGE Process automatically swages them from flat stock. By doubling the production rate and eliminating scrap, this advanced process can save you as much as fifty percent of the cost of other methods.

**The BEAD CHAIN MULTI-SWAGE** Process produces a wide variety of hollow or solid metal parts—beaded, grooved, shouldered—from flat stock, tubing, rod, or wire—of any metal. Sizes to ¼" dia. and 1½" length.

**GET COST COMPARISON ON YOUR PARTS**—If you use small metal parts in quantities of about 100,000, don't overlook the almost certain savings of this high-speed, precision process. Send sketch, blueprint or sample part and our engineers will furnish facts about Multi-Swage economy. Or, write for Catalog. The Bead Chain Manufacturing Co., 60 Mountain Grove St., Bridgeport, Conn.




**BEAD CHAIN MULTI-SWAGE PROCESS**
TRADE MARK

# Positions Wanted

*(Continued from page 56A)*

**JUNIOR ENGINEER**

Graduated June 1949 from Newark College of Engineering, Newark, New Jersey, with a B.S.E.E. degree. 3 years training and experience as radio technician in the Signal Corps. Age 30, married. Desires employment as electrical or electron engineer particularly in the high frequencies anywhere in U.S. or Canada. Box 358 W.

**SALES ENGINEERING OR TECHNICAL ADMINISTRATION**

Well-known, highly experienced and realistic engineer-consultant-writer in radio-electronic nucleonic fields, presently in California, seeks new employment anywhere. Particularly qualified in sales engineering, public relations and promotion of new developments. Very familiar with governmental, industrial and educational electronic circles nationwide. Box 359 W.

**JUNIOR ENGINEER**

Graduate student of radio and television desires junior engineering position in electronics industry. Particularly interested in audio or recording field. Broadcast experience. Age 23, married, child. Willing to travel occasionally. Prefer midwest or south. Box 360 W.

**ENGINEER**

B.E.E. June 1949, New York University, communications major. Age 23. Single. Eta Kappa Nu, Tau Beta Pi. Would like to start career in any of following fields: Hf, VHF and/or micro-

*(Continued on page 58A)*


*Senior Electronic Circuit Physicists*

for advanced Research and Development

Minimum Requirements:

1. M.S. or Ph.D. in Physics or E.E.
2. Not less than five years experience in advanced electronic circuit development with a record of accomplishment giving evidence of an unusual degree of ingenuity and ability in the field.
3. Minimum age 28 years.

HUGHES AIRCRAFT COMPANY

(Mr. Jack Harwood)

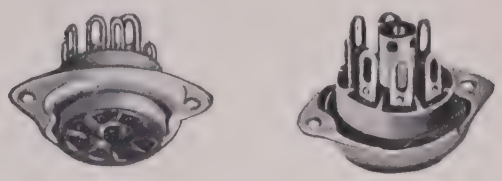
Culver City, California



*Announcing*

# MYCALEX 7 Pin Miniature Tube Sockets

For the first time a miniature tube socket of glass-bonded mica has been produced successfully by injection molding. It permits closer tolerances, low dielectric loss with high dielectric strength, high arc resistance and dimensional stability over wide humidity and temperature ranges. The technical skill and research of Mycalex Corp. of America has made it possible to produce insulating materials with extremely low loss factors at competitive prices.



Above: Complete 7 pin miniature Mycalex socket. Actual size, two views.

"Mycalex 410" was developed for applications requiring close dimensional tolerances not possible in ceramics and with much lower loss factor than mica filled phenolics with the advantage in economy.

"Mycalex 410X" was developed to compare favorably with general purpose bakelite in economy but with a loss factor of only about one-fourth of that material.

The following ratings show the difference between Mycalex 410 and Mycalex 410X miniature tube sockets.

| MYCALEX 410 (color grey) | | MYCALEX 410X (color lt. green) |
|---|---|---|
| 600 V.ac | Rated Working Voltage | 600 V.ac |
| .015 | Insulation loss factor (at 1 M.C.) | .083 |
| 10,000 megohms | Insulation resistance (Minimum) | 10,000 megohms |
| | Safe operating temperatures: | |
| 80° C. | Brass contacts | 80° C. |
| 375° C. | Socket body | 375° C. |

These superior sockets are now available, manufactured to high quality standards and fully meet RMA recommendations. We would be glad to have our engineers consult with you on your particular design problems. Write for prices, complete data sheet and samples to:

Mycalex Tube Socket Corporation

"Under Exclusive License of Mycalex Corporation of America"

30 Rockefeller Plaza, New York 20, N.Y.

MYCALEX CORP. OF AMERICA

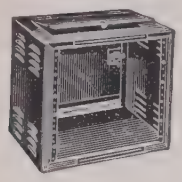
SINCE 1931 MYCALEX REG. IN U.S. PAT. OFF.

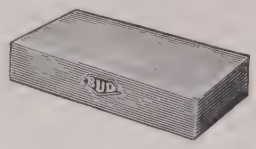
"Owners of 'MYCALEX' Patents"

Plant and General Offices: Clifton, N. J. Executive Offices: 30 Rockefeller Plaza, New York 20, N. Y.

R-1744 - AC-406 - CR-1728 - AC-407 - CR-1745 - AC-408 - CR-1741 - AC-409 - CR-17
CR-1739 -
# BUD HAS YOUR NUMBER IN CABINETS AND RACKS
- CR-1743 -
R-1740 - AC-403 - CR-1742 - AC-421 - CR-1739 - AC-404 - CR-1743 - AC-422 - CR-172

**In response to wide spread demand Bud has now augmented its already large line of Deluxe Cabinet Racks and Aluminum Chassis by the addition of several new sizes. The table below lists these new sizes as well as the old ones. Now, more than ever, Bud is able to meet your needs in sheet metal as well as other radio and electronic components.**






### BUD DE LUXE CABINET RACKS

These cabinet racks have rounded corners and attractive red-lined chrome trim. There is a recessed, hinged door on the top with a snap catch. These racks are made of heavy gauge steel and are of sturdy construction. The five large sizes have a hinged rear door, while the small sizes have a welded panel in the rear.

Adequate ventilation is assured by means of louvered sides and a two inch opening in the bottom of the back extends the entire width.

"NO-SCRATCH" EXTENDED METAL FEET ARE EMBOSSED ON THE BOTTOM TO MINIMIZE MARRING OF A TABLE TOP. Racks are furnished in either black or grey wrinkle finish. Depth 14¾" width 22" Will fit standard 19" panels.

| Catalog No. | Overall Height | Panel Space | Shipping Wt. | Dealer Cost |
|---|---|---|---|---|
| CR-1741 | 10 9/16" | 8¾" | 29 lbs. | $10.05 |
| CR-1740 | 12 5/16" | 10½" | 31 lbs. | 11.32 |
| CR-1742 | 14 1/16" | 12¼" | 32 lbs. | 12.25 |
| CR-1739 | 15 13/16" | 14" | 36 lbs. | 13.85 |
| CR-1743 | 19 5/16" | 17½" | 40 lbs. | 16.77 |
| CR-1727 | 22 13/16" | 21" | 45 lbs. | 18.00 |
| CR-1744 | 28 3/16" | 26¼" | 50 lbs. | 19.20 |
| CR-1728 | 33 5/16" | 31½" | 55 lbs. | 21.20 |
| CR-1745 | 36 13/16" | 35" | 60 lbs. | 21.57 |

**BUD ADD-a-RACK SERIES**

**Write for literature on this newest Bud product. Find out how you can get more panel space in less floor area at lower cost.**

### BUD ALUMINUM CHASSIS

The construction and design of these chassis is exactly the same as our steel chassis. The aluminum chassis are welded on government approved spot welders that are the same as used in the welding of aluminum airplane parts. The gauges in table below are aluminum gauges. As a result, you can depend on BUD Aluminum Chassis to do a perfect job. Etched Aluminum finish.

| Catalog Number | Depth | Width | Height | Gauge | Dealer Cost |
|---|---|---|---|---|---|
| AC-402 | 5" | 7" | 2" | 18 | $ .69 |
| AC-403 | 5" | 9½" | 2" | 18 | .81 |
| AC-421 | 5" | 9½" | 3" | 18 | .89 |
| AC-404 | 5" | 10" | 3" | 18 | .99 |
| AC-422 | 5" | 13" | 3" | 18 | .98 |
| AC-405 | 7" | 7" | 2" | 18 | .81 |
| AC-406 | 7" | 9" | 2" | 18 | .90 |
| AC-407 | 7" | 11" | 2" | 18 | .96 |
| AC-408 | 7" | 12" | 3" | 18 | 1.14 |
| AC-409 | 7" | 13" | 2" | 18 | 1.02 |
| AC-411 | 7" | 15" | 3" | 16 | 1.68 |
| AC-423 | 7" | 17" | 3" | 16 | 1.43 |
| AC-424 | 8" | 12" | 3" | 16 | 1.38 |
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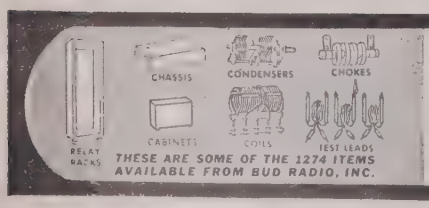
| AC-412 | 8" | 17" | 3" | 16 | 1.77 |
| AC-413 | 10" | 12" | 3" | 16 | 1.44 |
| AC-414 | 10" | 14" | 3" | 16 | 1.92 |
| AC-415 | 10" | 17" | 2" | 16 | 1.80 |
| AC-416 | 10" | 17" | 3" | 16 | 2.04 |
| AC-426 | 11" | 17" | 2" | 14 | 1.89 |
| AC-417 | 11" | 17" | 3" | 14 | 2.40 |
| AC-418 | 12" | 17" | 3" | 14 | 2.52 |
| AC-419 | 13" | 17" | 2" | 14 | 2.25 |
| AC-420 | 13" | 17" | 3" | 14 | 2.67 |
| AC-427 | 10" | 17" | 4" | 14 | 2.36 |
| AC-428 | 13" | 17" | 4" | 14 | 3.05 |

*Prices are 10% higher west of the Mississippi River.*

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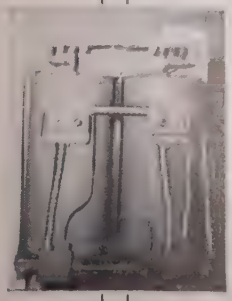

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*(Continued from page 57A)*

wave communications; instrumentation; general electronics. Will work in design, development or manufacture. Location immaterial. Richard A. Davidson, 2043 Holland Ave., New York 60, N.Y.

### ELECTRONIC ENGINEER

B.E.E. Polytechnic Institute of Brooklyn, June 1948. Experience includes 1 year as communications project engineer and several months test and development of radiation circuits and equipment. Desires position as project or development engineer in New York City or vicinity. Box 361 W.

### ELECTRONIC ENGINEER

M.S.E.E. University of Illinois, 1949; B.S.E.E. Purdue University, 1948. Age 27. Single. 2 years teaching experience in electronics. Member Eta Kappa Nu. 1st Radiotelephone and Class A Amateur Licenses. Desires employment in electronic research and development. Box 362 W.

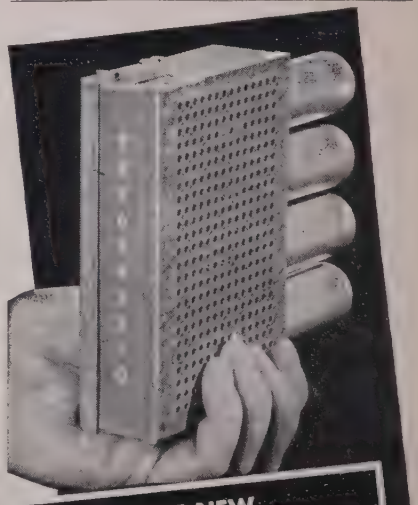
### ENGINEER

B.E.E. 1943. Postgraduate work in servomechanisms, circuit analysis, etc. 6 years experience in electronic instrumentation, guidance and control of guided missiles, digital and analogue computers. Box 363 W.

### TELEVISION ENGINEER

B.S.T.E. November 1948. American Television Institute of Technology. Age 29, married. 3 years Naval experience in electronics; 6 months in industry. 1st class FCC license. Desires position as TV station engineer. Box 364 W.

*(Continued on page 61A)*



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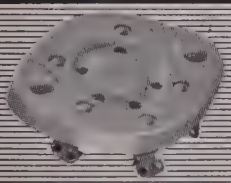

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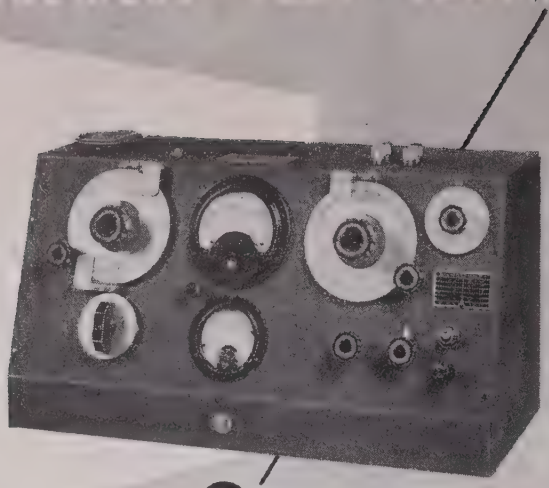

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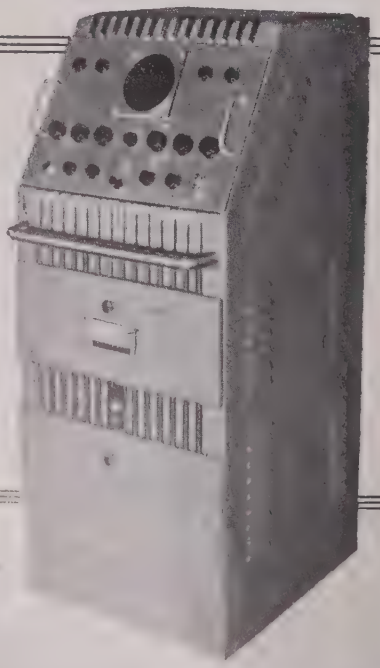

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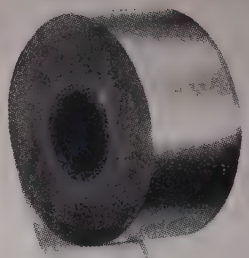

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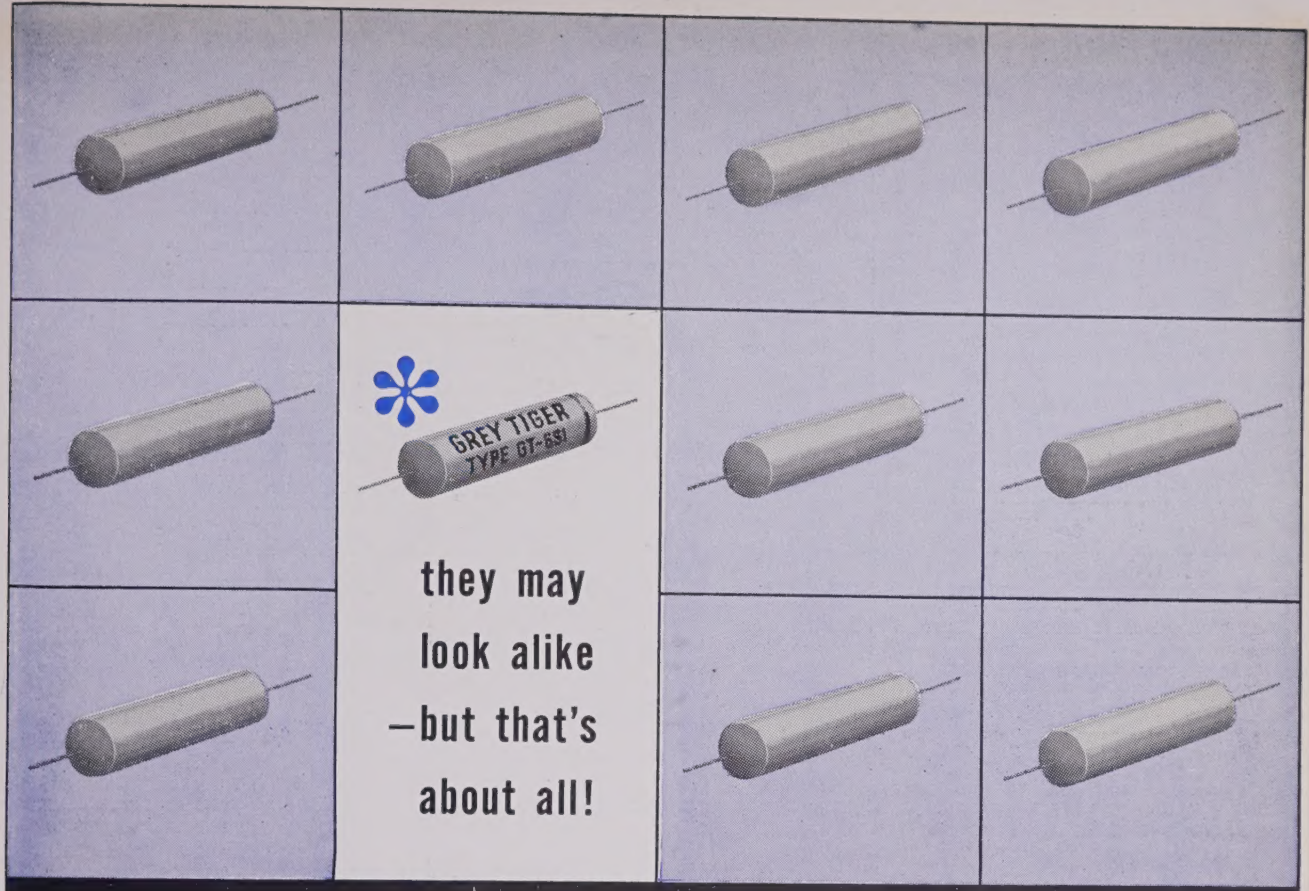


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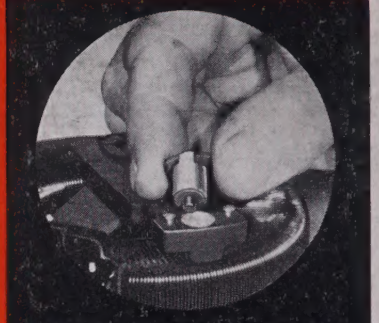

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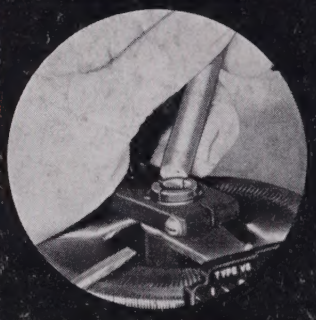
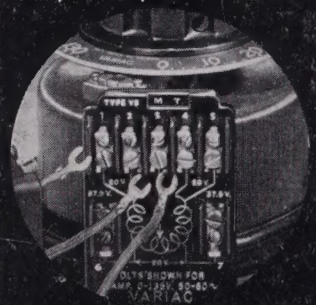


For changing to behind-the-panel or to table mounting the brush, radiator, collar, etc. are not disturbed. Just the shaft, dial and knob, as a unit, are removed.

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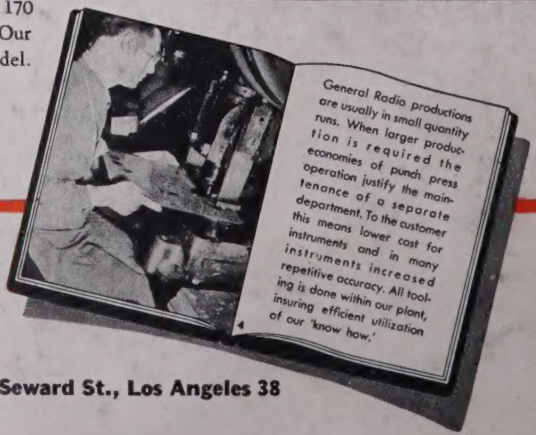



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